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Existing Techniques and Modern Developments in Recycling of Plastics Leading to Sustainability

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Abstract

Plastics are lightweight, inexpensive and durable. It can be easily molded into variety of Products. Over the last 60 years, the production of plastics has increased substantially. But only 15-20% of the plastics are being recycled. Moreover, the current usage and disposal methods can cause severe environmental problems. Major portions of plastics are produced for single use (packaging) and disposable purposes.

Recycling is one of the most important processes to be done to reduce the impact of the plastic industries today. Recycling helps in controlling consequential environmental effects as well as supports sustainability to a great extent. It also provides opportunities to reduce oil usage and emission of carbon dioxide. Nowadays innovations are made on manufacturing biodegradable products which is environment-friendly and recycling is not necessary. Advances in collection, sorting, recycling can also create further opportunities. Here, we focused on the current plastics recycling techniques and new developments.

Keywords: Plastics; Recycling; Innovations using plastics; Sustainablity

Introduction:

The very first synthetic polymer was synthesized in the year 1907. Ever since then the pros of such polymers including their low cost, and efficient properties like their durability has led to widespread uses of them throughout the world. The usage of plastics specifically has become so common that the Glob Production of plastics is estimated to exceed 500,000,000 metric tons in the next 29-30 years.This rising production, combined with rapid disposal and poor mechanisms for recycling, has led to the prediction that, by 2050, there will be more plastic in the sea than fish. Most plastics are produced for single-use applications, and their intended use life is typically less than 1 year. Yet, they tend to exist, for centuries, in the environment. Even after about 4 decades of the recycling initiative which began with a launch of the infamous symbol, the amount of plastics that are recycled is only about 5% of the total. With growing demands for usage, the need for recycling is also rapidly growing.

Existing methods of recycling plastics

Hydrolysis

Hydrolysis leads to direct recovery of the original raw materials by targeted reaction of water molecules at the linkage points of the starting materials thus reversing the polymerization process. Molecular degradation is caused by Hydrolysis, where Plastic components will fail. It is associated with the degradation mechanism which causes alterations of molecular structure.

The most common mechanisms that occur are thermal oxidation, ultraviolet radiation, chain scission, and hydrolysis.

Alcoholysis

Chemical degradation of polyurethanes can also be achieved by alcoholysis to give a polyhydroxy alcohol and small urethane fragments formed by transesterification. These polyhydroxy alcohols can be converted directly to polyurethane foam following the addition of isocyanates and varying proportions of new polyhydroxy alcohols. Polyesters and Polyamides can also be alcoholised.

Hydrogenation

In hydrogenation the C – C bonds of polyolefins and polystyrene are broken by the addition of hydrogen. Alkanes constitute a largest group of products resulting from the process of mild decomposition. Since other bonds (e.g., ester bonds) can also be cleaved by hydrogenation, most types of plastic can be degraded in this way and therefore the plastic waste does not require sorting.

Pyrolysis

Pyrolysis is thermal cleavage in complete or partial absence of air, accompanied by simultaneous generation of pyrolysis oils and gases suitable for chemical utilization or energy generation. Thermoplastics, thermosets, elastomers, composite materials, and heavily soiled or damaged plastics can be recycled by pyrolysis. The advantage of pyrolysis over combustion is the 5- to 20-fold reduction in the volume of product gases which leads to considerable savings in gas purification.

Combustion

If it is not practical or economic to reuse plastic waste, it is still possible to make use of its energy content by Combustion Process. The calorific value of 1 kg of plastic waste is roughly that of 1 L of fuel oil. Halogen and Nitrogen containing plastics should not be used for combustion process as it releases toxic gases during the process.

Dumping

Large quantities of plastic waste are dumped with household garbage. Since plastics are usually insoluble and harmful substances are not washed out, they do not cause any increased environmental burden in a well-managed dumping site. The plastic waste is unlikely to decompose under dump site conditions and will persist over a long period. Many of the products that we use daily are flushed down toilets, including tissue papers, wet wipes, sanitary products, cotton buds. Microfibres which are even released in the waterways when we wash our clothes in the washing machine. They are too small to be filtered out by waste water plants and end up being consumed by small marine species, eventually even ending up in our food chain.

Degradation

Degradation of plastics to give materials of lower molecular mass can be affected by heat, light, and both chemical and biological processes. One possibility is to manufacture plastics which, after use, are degraded by the influence of light or microorganisms. However, the degradation products may have a greater adverse impact on the environment than the plastics in their original form. By the catalytic activity that cleave polymeric plastics into oligomers, dimers or monomers by ecto-enzymes or free-radicals secreted by microorganisms and also by biochemicals. The bio-deterioration seems to be triggered by the formation of a microbial biofilm growing inside the plastic. The development of the biofilm in the plastic, but also on the environmental conditions.

Degradation By Uv Radiation

Stabilizers are usually added to plastics to protect them against the effect of light. To make them more sensitive to light, UV-absorbing monomers can be added. This is best achieved by incorporation of carbonyl- containing materials, the chains of which break down under the influence of light to give lower molecular mass compounds. Other possibilities include adding sensitizers to the polymerization mixture.

Biodegradation

With the exception of some cellulose derivatives and aliphatic polyesters, most synthetic polymers are not attacked by microorganisms. . Terpolymers of ethylene, carbon monoxide, and vinyl acetate undergo slow biological degradation. Incorporation of cellulose and starch and Adding additives such as plasticizers and lubricants can increase the rate of biodegradation (which depends on moisture content.)

Gasification

Municipal wastes like paper and textile wastes, including plastics, are gasified under low-oxygen conditions which results in the formation of a mixture of hydrogen and monoxide of carbon. This synthesized gas in turn acts as a raw material for chemical production. Gasification plants are however expensive. Gasification process requires financing initially. It requires clean up facilities, separating unit of gases, pre-treatment, advanced control system and this process can be done for 5000 tonnes of Plastics per year.

Solvent-Based Processes

Solvent processes dissolve polymers for filtration of impurities which helps in easy reconstitution of the polymer. These processes do not completely break-down the polymers by by chemical reactions.

The result is nearly equivalent to virgin polymers. This process is used for recycling polymers like polystyrene, polypropylene, etc.

New developments in recycling plastics

Chemical Recycling

Chemical recycling is a process in which a polymer (here, a plastic) is reduced chemically to its constituent monomer form so that it can be re-polymerized and remade into new plastic products. Chemical recycling with thermolysis offers a recycling strategy through decomposition of a polymer to lower-molecular-weight products. [7] Challenge posed however, is that depolymerization to monomers will require the development of catalysts that are selective, efficient and preserve the functional groups in monomers while meeting requisite cost and energy metrics.

Recycling Of Commingled Plastics

Single-stream or fully-commingled recycling is a technique in which all types of plastics are collected and handled together instead of being sorted separately. The biggest disadvantage when it comes to recycling of commingled plastics is that most plastics are immiscible with one another. They produce mixtures that are separated by differences in their phases with diminishing properties. The presence of even a small amount of one plastic in another affects the properties to a great extent and prevents the desired use of the recycled material.This problem can be overcome through the development of compatibilizers that control the phase behaviour of polymer mixtures.

Compatibilizers

Still an area of research, polymer compatibilizers are multicomponent polymers of various architectures (block copolymers, graft co-polymers, and random copolymers) that are designed to have thermodynamic interactions with the immiscible polymers in the mixture. They are similar to surfactants. Applying polymer compatibilizer design principles to plastic solid waste would allow for more widespread recycling without pre-sorting. Simply, compatibilizers are additives which can be added to two types of plastics which forms a bonded, stable final product. These additives facilitate recycling of immiscible plastics.

Development Of Smart Plastics

Smart plastics are high performance polymers that respond to stimuli and change their visual, optical, electrical, permeable properties, etc. accordingly. The stimuli can be anything – from temperature, pH to humidity or electrical and magnetic waves. Even a slight contact with any of the mentioned stimuli can cause huge property changes in the polymer. This is useful to separate a mix of different types as well as immiscible plastics for recycling. This is helpful in overcoming the crucial separation process, which is much easier in case of metal wastes.

Current Advances

Innovations in recycling technologies over the last decade include increasingly reliable detectors and sophisticated decision and recognition software that collectively increase the accuracy and productivity of automatic sorting, like FT-NIR detectors. Several start-ups have come up with different and unique ideas for recycling, few of which are discussed are below:

Startup like BioCellection developed Plastics recycling using chemical process. Where it converts post-consumer Plastic Product into the Building blocks. This process involves synthetic biology and chemistry. Chemicals which were extracted from grocery bags, trash bags, food covers and potentially replace resource for fossil fuels.

The NexGenCup US based startup recycling single use Plastics. Single use paper and Plastics are incomprehensible. Over half trillion of disposal cups are sent to landfills. Through this chlorine content released in water. Where release of carbon dioxide and other pollutants make impact on earth.

Australian startup Newtechpoly develops recycling technology for Plastics called Polywaste Technology. The difference between traditional plastic recycling technology and PolyWaste Technology is that it can recycle all variety of Plastics and combination of contaminated film. Rigid, semi rigid Plastics which were from Industries, Commercial, Agricultural and Domestic wastes convert into value added Product

Conclusion

Plastics recycling is a substantial area of research that scientists and technologists all over the world are very much invested in. Though several techniques have been developed till date, each method has a minute detriment that might lead to unanticipated environmental aftermaths. The discovery of an apt recycling technique is something that's been worked on everyday. With new materials being discovered daily, the challenges posed are growing unquestionably. Existing methods prove to be efficient, but they are not promising for the future. With new situations massively arising and contributing to plastic waste, like the current COVID-19 pandemic, the demand for recycling is unquestionably increasing. Discarding plastics with improper disposal methods has resulted in several visible environmental effects which is forcing each individual to consider recycling more seriously. The need of recycling has been very well apprehended and insisted, which is believed to lead the way to disclosing toxic-free approaches to recycle plastics. Sustainability is defined as the ability to meet our needs without compromising the needs of the future generation. Recycling is believed to be one of the significant steps towards a sustainable future, which will definitely pave a tremendous way for the future generation's demands.

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