ABSTRACT

Plastic waste remains one of the biggest problems globally. Piles of plastic waste have become a common site in towns, and the menace is rapidly spreading to the countryside. Plastics have become an indispensable part of our daily life. But repeated reprocessing of plastic waste and its disposal creates environmental problems, pose health hazards. Although plastics pose a hazard to the environment because they do not decay, plastics are preferred because they are cheap and versatile. Virtually every known plastics material is used in some aspect of packaging. After using packaged item the plastics wrapper, bag, or container is merely a waste. The huge amount of waste generated by industry and the consumer can not be ignored. Plastics waste becomes nuisance for human beings. To overcome this problem one can reduce the use of polymer films which in turn will result in consumption of scarcely available material i.e. wood, minerals, metals, crops etc; manufacture films having thickness greater than 20 microns this in turn will result in consumption of more material i.e. greater cost and more material to be disposed; develop a fully degradable polymer having all the properties comparable with that of the conventional polymer. Researchers are working hard in this area. Various mechanisms of polymer degradation are studied. Hence various factors affecting polymer degradation, the extent of degradation, the duration of degradation and their effect on the property of polymer are studied. Also the naturally available polymers and water soluble polymers are studied with respect to their properties, processing ease and the cost. Amongst the main factors affecting the degradability viz. Additives, Plasticizers, Water uptake, Crystallinity and molecular weight, the type of chemical bond, Copolymer composition, pH and Enzymatic degradation; the additives and the water uptake are the most studied modes in the development of biodegradable polymers. Amongst the

additives the starch, protein, carbohydrates etc. based polymers have become the most conventional modes of biodegradable polymers.

THE LIMITATIONS of biodegradable polymers available in the market are:

◊The naturally available polymers do not possess the strength and processing ease like the conventional polymers used to manufacture carry bags. Hence they find applications mainly in the medical field.

◊The water soluble polymers dissolve in water hence pollute the water, which in turn do not solve the environmental problem.

◊The polymers with starch, protein or carbohydrates as additives show only the fragmentation i.e. only the additive content is biodegraded leaving the polymer part intact. To reduce the polymer part in the environment the additive amount is increased (Up to 90%). But as the additive amount increases the strength reduces. Thus the additive based option does not fully solve the environmental problem.

◊The plasticizers when added to the natural polymers do not improve the tensile strength of the polymer and thus in turn do not help in improving the ease of processing. (J. W. Lawton, 2004).

TO OVERCOME THESE PROBLEMS out of various factors affecting the polymer degradation; plasticizer was selected. The basic principle was all plasticizer tends to force the polymer chain apart, giving them greater freedom of movement and also reducing van der Waals' forces between the chains. When the binding forces between the chains are reduced, it will be easier for the microorganism to attack on the weakened, individual chains and get their required nutrition for the growth and thus the degradation can be continued. Since there are no plasticizers that are completely free from fungal or bacterial attacks and susceptibility of microbial attack increases as the plasticizer level increases the plasticizer can most effectively degrade the polymer. The effects of various plasticizers were studied and the most suitable with respect to availability, ease of processing and cost i.e. groundnut oil and soy bean oil were selected. The most conventional polymers used for the manufacture of carry bags i.e. LDPE, HDPE, PS and PP was selected. The polymers were processed by the conventional intermittent extrusion process. The mechanical strength of the plasticized polymers was comparable with those of conventional materials. The films manufactured were subjected to the mixed culture of microorganisms exhibiting the highest susceptibility towards the biodegradation. Various standard test methods for the assessment of biodegradation i.e. Screening of biodegradation of specimen in open air to assess the property loss, Screening of biodegradation of specimen in open air, Growth ratings ASTM G-21 and Plant toxicity test were applied. Great loss in viscosity, mechanical strength was observed which in turn assures the biodegradability of the films.

PROPERTY LOSS DUE TO DEGRADATION AFTER 12 WEEKS:

Sr. no.	Specimen	Weight loss	Percent loss in tensile strength	Percent elongation loss	Specific viscosity
1.	LD00	6.943	65.619	95.833	125.627
2.	LDG25	1.600	68.541	137.5	50.192
1.	LDS25	11.767	69.493	577	59.249
2.	HD00	4.675	69.021	379.222	660.897
3.	HDG25	5.067	76.783	555	280.899
4.	HDS25	4.867	92.968	78.256	791.521
5.	PS00	0.200	99.483	-13.278	122.457
6.	PSG25	6.127	98.441	-3.839	24.953
7.	PSS25	11.600	82.938	-1.715	45.249
8.	PP00	0.650	86.909	129.488	400.101
9.	PPG25	2.750	61.492	246.429	293.059
10.	PPS25	7.200	72.591	543.092	181.650

After 12 weeks fragmentation into extremely small pieces of the specimens was observed and all the specimens were mixed up. Hence the loss in mechanical strength and viscosity could not be measured. But from the loss in mechanical properties and viscosity it could be inferred that the polymer chains with high molecular weight were converted into small chains with low molecular weight. To identify the specific specie of the microorganism affecting the biodegradability the specimen were subjected to the concentrated culture of six microorganism that exhibit the highest susceptibility towards the biodegradation i.e. Pseudomonas (Bacteria), Staphylococcus (Bacteria), E- Coli (Bacteria), Aspergillus Niger (Fungi), Rhizopus (Fungi) and Consortium - Mixed Culture of above microorganisms were selected. The specimens were placed in open air so that other environmental factors and microorganism can also affect the biodegradability. After 16 weeks typical color change and higher growth was observed in some specimen. The medium from those specimens were collected for further identification of microorganism. The study of microorganisms that were isolated and grown separately revealed that the original structure of the microorganism Aspergillus Niger was changed depending upon the nutrition available and environmental factors affecting the microorganisms i.e. Aspergillus Niger was formed with LDPE and PS, Aspergillus fumigatus was formed with HDPE, Aspergillus ustus was formed with PP. Also the growth of some unidentified fungi was also observed. The traces of other microorganisms that were initially used i.e. Pseudomonas (Bacteria), Staphylococcus (Bacteria), E- Coli (Bacteria), Aspergillus Niger (Fungi), Rhizopus (Fungi) were not seen in the residue of the biodegraded films.

The films from HDPE, PS and PP could not be produced by the conventional screw extruder. Due to their crystalline nature they could not retain the plasticizer in the polymer matrix. During the extrusion the plasticizer exudes out of the polymer. Hence a film from the polymer exhibiting good degradability and ease of processing i.e. LDPE was manufactured on large scale on a conventional screw extruder. Due to the effect of plasticizers on the processing various processing parameters were lowered. The cost analysis of LDPE film revealed up to 1.67 times saving in raw material for manufacturing films of a given strength. The films were subjected to the plant toxicity test to assess the effect of biodegradable polymer on the production of crops. The soil analysis revealed that the fertility of the soil after land fill was improved i.e. the carbon content of the soil was increased from 31% to95%.

FUTURE RESEARCH SCOPE:

◊The effect of specific specie of microorganism on the biodegradation of polymer under contamination free environment can be studied.

◊The biological system affecting the biodegradability of un plasticized specimen can be identified.

◊Procedures for reproducibility of the biological system that affect the biodegradability can be developed.

◊ The path of biodegradation can be studied by the electron microscopy.

◊The mixing device for uniform mixing of plasticizer in the polymer can be designed.

◊Proper additives for the crystalline polymer like HDPE, PS and PP can be identified so that the plasticizer can be retained in the polymer matrix without adversely affecting its biodegradability.

◊Device to measure the precise viscosity of the polymer after subjecting to the microorganism can be designed.

◊Procedure to analyze the biomass-residue from the screening test for biodegradability can be designed so as to identify the composition of the residue.