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Biodegradability Test of Biocomposites of Poly Styrene Reinforced by Woven Hybrid Palm-Cotton Fiber

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***Abstract*: Woven palm-cotton hybrid fiber reinforced polystyrene biocomposites with different weight % of Poly Styrene (PS) are taken for study. The biodegradability of the samples were analysed by soil burial method over a period of 90 days. The samples are removed periodically after 1, 7, 14, 21, 30, 45, 60, 75 and 90 days of incubation time and weight loss % is found out. The results showed that all the samples are biodegradable and their biodegradability increases with decrease in weight% of polystyrene.**

***Keywords*: Biocomposite, biodegradability, soil burial method, woven palm-cotton hybrid fiber**

1. Introduction

Plastics have become indispensable in many ways due to their low cost, durability, strength and versatility. Petroleum-based synthetic polymers are widely used in modern society since the physical and chemical properties of plastics make them ideal materials for a variety of products and applications. However, the annual worldwide disposal of approximately 150 million tons of petrochemical plastics is a significant environmental problem, especially with the continuously increasing production and consumption of these materials [1]-[6]. Ecological concerns and the impending depletion of fossil fuels are driving the development of new bio-based, green products [7]-[8]. Developments of biodegradable plastics or modifying the existing ones to make them biodegradable have become the focus of research world.

Natural fiber reinforced composites as alternative to artificial fiber composites have advantages like renewable, environmental friendly, low cost, light-weight, and high specific performance ascribed to the natural fiber. The biodegradability of plastics is dependent on the chemical structure and constitution of the composites. Biodegradation is brought about by biological activity predominantly by enzymatic action of micro-organisms and can be measured by standard tests in a specified period of time. Biodegradability of the biocomposite is the most attractive factor in selecting it as substitute for plastics in various application sectors. Biodegradation process of polymer biocomposites involves the enzymatic action of microbes such as fungi or bacteria on them to produce CO_2, H_2O, and non-toxic biomass. During this process, microbes utilize the biopolymers as nutrient and thus, cause the biophysical damage of thermoplastics. Due to the growth of cells, initially, the mechanical damage is caused and then followed by the ultimate degradation of thermoplastics. The onset and rate of biodegradation of biocomposites are highly influenced by several environmental factors such as moisture, light, nutrients, and temperature. The biocomposites with high water absorption are more prone to the microbial attack, which implies that the hydrophilic nature allows the microbes to attack the interior of polymer matrix using water as a medium. Biodegradability tests are categorized into laboratory and field trials. Biodegradation is evaluated by percentage weight loss and morphological analysis.

Over the past few years, considerable number of studies has been performed on biodegradable composites containing biodegradable plastics with reinforcement of biodegradable natural fibers [9] but studies carried out or reported on biodegradability of composites made of synthetic polymers reinforced with natural fiber are very less. Sanjay K. Chattopadhyay et.al. [10] studied the biodegradability of synthetic polymer, poly propylene reinforced with natural fibers like pine apple leaf fiber, banana and bamboo fiber. Test results revealed biodegradability in the range of 5-15% depending on the fiber content. Though not excellent, it assures minimum polymer waste by incorporating renewable natural fiber. Liu. et. al. [11] have studied importance of different natural fiber and composites made from it. They also provide the information about mixing of different natural fibre with biodegradable and bio re-storable polymers and their application in different area [12].

In this regard, biocomposite prepared from synthetic polymer Poly styrene which is widely used thermal insulation material reinforced with hybrid palm-cotton natural fiber is taken for study. Biodegradability of the composites are studied by soil burial method. Weight loss method was adopted and variation in biodegradability with different weight percentage of poly styrene was analysed.

2. Experimental

A. Materials

1) Soil

Soil used in this test was collected from different cultivation areas such as pea, banana, and paddy field and mixed in 2:1:1 ratio. The water content and pH of the soil were maintained at 65.0% and 7 respectively.

2) Test specimens

The samples prepared with different weight percentage of poly Styrene with fixed fiber content is taken. Biocomposite of woven palm-cotton fiber with 5%PS, 10%PS, 20%PS, 30%PS, 40%PS are taken. To get the two extremes of biodegradability mere Polystyrene and pure woven palm-cotton fiber samples are also taken. Samples with dimensions 10×10× 0.1mm^3 were dried for 24 h in a vacuum oven (60°C, 700 mm of Hg) and weighed. These samples are buried in soil.

B. Method

Soil burial method was adopted to study biodegradability of the samples and biodegradability assessed by weight loss method. The biocomposites with dimensions 10×10×0.1mm^3 were dried for 24 h in a vacuum oven (60°C, 700 mm of Hg) and weighed (W1). Each sample was buried approximately 10 cm under the biologically active soil surface contained in rectangular plastic bags. To ensure the conditions such as fresh oxygen supply and natural environment for the degradation of samples in plastic boxes, they were kept in open space. Soil used in this test was collected from different cultivation areas such as pea, banana, and paddy field and mixed in 2:1:1 ratio. The water content and pH of the soil were maintained at 65.0% and 7 respectively. Samples were removed periodically after 1, 7, 14, 21, 30, 45, 60, 75 and 90 days. Then washed thoroughly with distilled water and dried for 24 h in a vacuum oven (60°C, 700 mm of Hg) and weighed (W2). From the initial and final weight, weight loss percentage can be calculated by the equation given below.

$$\text{Weight Loss (\%)} = \frac{(W_1 - W_2)}{W_1} \times 100$$

3. Result and Discussions

The figure 1 shows variation in weight loss (%) for all specimens after recovering at regular intervals of 7, 14, 21, 30, 45, 60, 75 and 90 days of soil burial study. It is evident from the study that mere poly styrene is not undergoing significant degradation. There is only a slight increase in% weight loss for Poly styrene (PS) due to the degradation.

The weight loss for woven Palm-Cotton Fiber sample and 5% PS containing biocomposite sample are significant after 7 days. It is due to the hydrophilic nature of these samples since it has less polymer content. Natural fibers are water absorbing and composites with hydrophilic nature and higher water absorption are more prone to the microbial attack, which provides easy access to the matrix interior using water as a medium [13]-[15]. Due to this composite with less weight % of poly styrene samples have more loss in weight %. All biocomposite samples undergo degradation. The degradation pattern reveals that biodegradability decreases with increase in weight percentage of polystyrene.

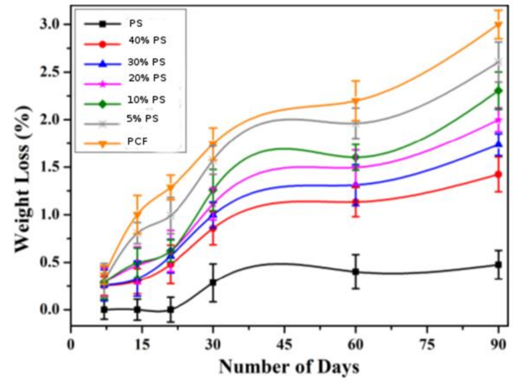

Fig. 1. Percentage weight loss of samples from soil burial degradation of biocomposites (Poly Styrene PS, Palm-Cotton hybrid fiber PCF)

4. Conclusion

Natural fibers such as palm, cotton reinforced poly styrene composites are taken for biodegradability study. Variation in biodegradability with different weight % of poly styrene was analysed. Studies revealed that all samples are biodegradable. The extent of biodegradation depends on the amount of polymer. The biodegradability decreases with increase in weight % of polystyrene. Thus, it can be concluded from the above that the natural fibers from renewable resources which act as a reinforcing agent in various synthetic polymers and commodity plastics can address to the management of waste plastics, by reducing the amount of polymer content used. This will definitely reduce the generation of waste of the non-biodegradable polymers.

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