Waste Management Option for Bioplastics Alongside Conventional Plastics

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***Abstract*—**Bioplastics can be defined as polymers derived partly or completely from biomass. Bioplastics can be biodegradable such as polylactic acid (PLA) and polyhydroxyalkonoates (PHA); or non-biodegradable (biobased polyethylene (bio-PE), polypropylene (bio-PP), polyethylene terephthalate (bio-PET)). The usage of such bioplastics is expected to increase in the future due to new found interest in sustainable materials. At the same time, these plastics become a new type of waste in the recycling stream. Most countries do not have separate bioplastics collection for it to be recycled or composted. After a brief introduction of bioplastics such as PLA in UK, these plastics are once again replaced by conventional plastics by many establishments due to lack of commercial composting. Recycling companies fear the contamination of conventional plastic in the recycling stream and they said they would have to invest in expensive new equipment to separate bioplastics and recycle it separately. Bioplastics are seen as a threat to the recycling industry as bioplastics may degrade during the mechanical recycling process and the properties of the recycled plastics are seriously impacted. This project studies what happens when bioplastics contaminate conventional plastics.

Three commonly used conventional plastics were selected for this study: polyethylene (PE), polypropylene (PP) and polyethylene terephthalate (PET). In order to simulate contamination, two biopolymers, either polyhydroxyalkanoate (PHA) or thermoplastic starch (TPS) were blended with the conventional polymers. The amount of bioplastics in conventional plastics was either 1% or 5%. The blended plastics were processed again to see the effect of degradation. Mechanical, thermal and morphological properties of these plastics were characterized.

The results from contamination showed that the tensile strength and the modulus of PE was almost unaffected whereas the elongation is clearly reduced indicating the increase in brittleness of the plastic. Generally, it can be said that PP is slightly more sensitive to the contamination than PE. This can be explained by the fact that the melting point of PP is higher than for PE and as a consequence, the biopolymer will degrade more quickly. However, the reduction of the tensile properties for PP is relatively modest. It is also important to notice that when plastics are recovered, there will always be a contamination that will reduce the material properties. The reduction of the tensile properties is not necessary larger than if a non-biodegradable polymer would have contaminated PE or PP. The Charpy impact strength is generally a more sensitive test method towards contamination. Again, PE is relatively unaffected by the contamination but for PP there is a relatively large reduction of the impact properties already at 1% contamination.

PET is polyester and it is by its very nature more sensitive to degradation than PE and PP. PET also have a much higher melting point than PE and PP and as a consequence the biopolymer will quickly degrade at the processing temperature of PET. As for the tensile strength, PET can tolerate 1% contamination without any reduction of the tensile strength. However, when the impact strength is examined, it is clear that already at 1% contamination, there is a strong reduction of the properties. It can also be seen that presence of TPS is more detrimental to PET than PHA is. This can be explained by the fact that TPS contain reactive hydroxyl groups that can react with the ester bond of PET. This will in other words lead to degradation of PET.

The thermal properties show the change in the crystallinity. As a general conclusion, it can be said that the plastics become less crystalline when contaminated. The blends were also characterized by SEM. Biphasic morphology can be seen as the two polymers are not truly blendable which also contributes to reduced mechanical properties. Recycling of the contaminated polymer shows an increase in crystallinity. This means that when the polymers are processed, polymer degradation occur causing the polymer chains to gradually become shorter which will enhance the crystallization process.

The study shows that PE is relatively robust againt contamination, while polypropylene (PP) is somewhat more sensitive and polyethylene terephthalate (PET) can be quite sensitive towards contamination.

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