Reinforcement of Biodegradable Sago Starch/Natural Rubber Latex (B-SSNRL) composites by Ultrafine Calcium Carbonate

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Introduction

Natural filler such as sago starch had been widely study as one of the abundantly natural and cheap biomaterials as replacement of conventionally un-degraded plastics or rubber products [1]. Incorporation of sago starch in NR Latex system improves the biodegradability of the materials upon disposal. Sago starch which is mainly consist of amylose and amylopectin group [2, 3] increase the interaction between rubber particles by forming protein bonding which also been utilized by microorganism as sole of energy sources [4]. However, the incorporation of thermoplastic sago starch decrease the physical properties of NR Latex films as its increase the amorphous region and lead into decreasing ability of the films to form stress induce crystallization during mechanical test [5]. To encounter these problems, calcium carbonate, which is already known as one of reinforcing fillers for NR latex, is used to maintain the biodegradable Sago Starch-NR latex films integrity.

Experimental

Materials

Natural Rubber Latex (NR latex) is supplied by Zarm scientific (M) Pte. Ltd, with TSC of 60%, DRC of 30%, and MST more than 20 min and VFA number less than 0.02.

Ultrafine Calcium Carbonate and Sago starch is supplied by Sigma Aldriech (M) Pte. Ltd with average size of 0.7 micron and 30 micron respectively was dispersed together with dispersing agent and stabilizer in water as medium by using ball mill machine overnight to reduce its particle size.

Apparatus and Procedure

All compounding ingredients were pre-mix by using conventional mechanical stirrer with NR latex and being prevulcanized at 70°C for 45 minutes before maturates at room temperature for 24 hours. Prevulcanized NRL films are prepared by dipping method using aluminum plates with dimension of 140mm x 150mm. 10 batch of compounds were prepared and buried in a separate compost soil with respect to week of taken out. One batch of NRL films were taken out weekly and being cut into dumbbell shape and tested by Instron Tensile Test machine to get its Tensile and Tear strength According to ASTM 412. Protein test are done according to ASTM D 5712 without correction by Malaysian Rubber Board to assess the correlation of protein content with the process of biodegradation over week. To assess the biodegradability of NRL films, films mass loss were calculated base on below formula;-

$$\frac{mass\ before\ burial,\ m_i - mass\ after\ burial,\ m_f}{mass\ before\ burial,\ \ m_i}$$

Results and Discussion

Physical properties

Table 1 indicates that the physical properties of B-SSNRL films were decreased as Sago starch loading increased. The result also indicates that optimum sago starch loading were achieved at 10 phr. The incorporation of calcium carbonate ($CaCO_3$) in optimum sago starch loading compounding increased the B-SSNRL films physical properties. Tear strength of the films seems to be increased as the sago starch loading increased in B-SSNRL films.

Table 1: Tensile and tear properties of B-SSNRL films and B-SSNRL films reinforced with $CaCO_3$

Filler Loading, (phr)	Tensile Strength, (MPa)	Tear Strength, (MPa)
$CaCO_3$ (10) + S (10)	21.1	64.5
0	22.3	54.1
5	18.3	57.9
10	19.2	61.6
15	17.4	62
20	16.9	63.2
25	15	65.3

Figure 1 represents the physical properties of B-SSNRL (together with B-SSNRL reinforced with $CaCO_3$ films) over weeks of biodegradation. Both tensile and tear properties of the films seem to be decreased over the period of biodegradation process.

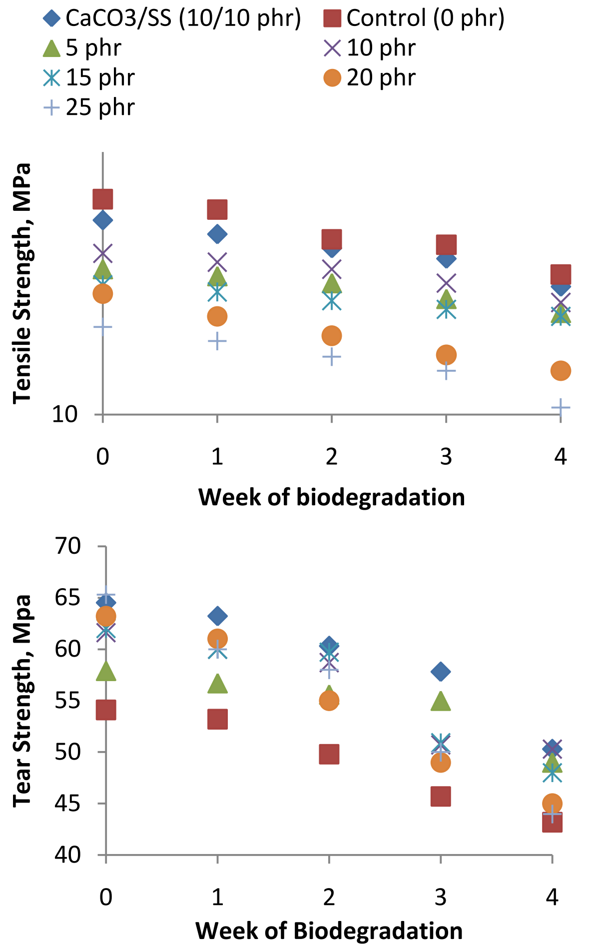

Figure 1: Tensile and Tear Strength for all B-SSNRL films over week of biodegradation

Protein analysis

Table 2: Extractable protein content for all B-SSNRL films

sample	µg/g	µg/dm2
CaCO3/SS (10/10	1412	828
Control (0)	1320	895
5	1453	1002
10	1316	1033
15	1511	1064
20	1557	681
25	1510	871

Table 2 indicates that the increment of protein content in B-SSNRL as the sago starch loading increased. For 10 phr sago starch loading, the decrement was detected. This is due to the effective protein bonding achieved between rubber particles and sago starch. As the biodegradation period elapses, the protein content for each films were decreased as represented in figure 2.

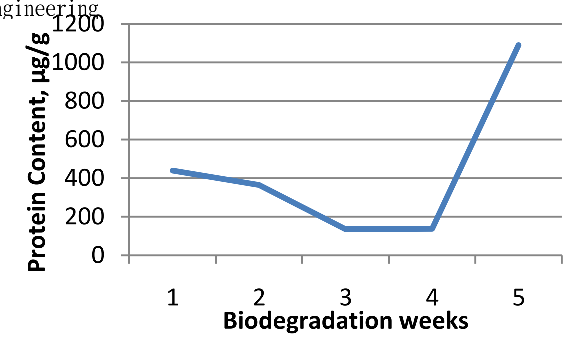

Figure 2: Protein content for B-SSNRL films over week of biodegradation

At week 4 the protein content increased tremendously. This is due to the increased of microorganism population on the films surface (ref.). The decrements of protein content in B-SSNRL films over biodegradation weeks confirm the utilization of protein substance as microorganism source of energy.

Mass loss

Figure 3 indicates the mass loss for B-SSNRL films for 4 weeks of biodegradation periods. All B-SSNRL films including the films which had been reinforced with $CaCO_3$ seems to loss it's mass periodically over week of biodegradation.

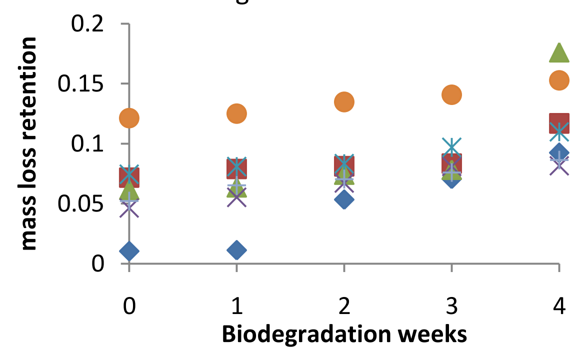

Figure 3: mass loss of all B-SSNRL films over weeks of biodegradation

Conclusion

Ultrafine $CaCO_3$ can be use as reinforcement filler for B-SSNRL films

References

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