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The Flow Properties of Sago Starch/Chitosan Blends

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Abstract: Blends consisting of a systematic compositional series of Sago Starch (SS) and chitosan (CS) were studied by using a Brookfield Digital Viscometer Model DV-II Version 2.0. The viscosity of pure SS, pure CS and SS/CS blends was measured over the temperature range 30-130°C. Results on the SS/CS blends indicate that the viscosity decreases with temperature and SS content for a fixed speed. At lower SS content, the decrease of viscosity with temperature is more pronounced. This indicates that blends with higher CS content are more affected by temperature changes. Blend containing 50%CS was superior compared to other blends and this finding is consistent with earlier works on compatibility studies of polypropylene/sago starch blend using Dynamical Mechanical Thermal Analyzer (DMTA).

Key Words: Sago Starch, Chitosan, Viscosity

Introduction

Considerable interest has been shown for the potential use of starch-based polymer blends to produce biodegradable plastics for applications such as disposable diapers, rubbish bags and compost bags. Sago Starch (SS) is a mixture of linear amylose and branch amylopectin polymer that is polysaccharides of α-D-glucopyranosyl units ($C_6H_{10}O_5$). The molecular weight of amylose is on the order of several hundred thousand, while that of amylopectin is several million. For most starches, crystallinity is attributed to short Degree of Polymerization (DP) chains of amylopectin (14-20 glucose units) (Robin *et al.*, 1992).

The amorphous phase of granular starch is also heterogeneous, consisting of amorphous amylose and intercrystalline regions of dense branching in amylopectin. The implication of such complex morphology is that the thermal properties and plasticization behavior of starch by water will vary throughout the amorphous phase (Biliaderis, 1992). Depending on the severity of thermo mechanical conditions, moisture content and presence of other constituents, separation of amylose and amylopectin phases can take place during processing, thereby resulting in a composite structure of the product.

Chitosan (CS) is of interest as a potential edible film component because of its excellent oxygen barrier properties (Conca and Yang, 1993; Anker, 1996). CS generally obtained from natural chitin after deacetylation by alkaline treatments, is a natural, nontoxic, biodegradable polymer (Sandford, 1989). It can be produced from shellfish waste, and is composed primarily of glucosamine, 2-amino-2-deoxy-D-glucose. Chitosan is commercially available and has been employed in a variety of applications (Sandford, 1989 and Winterow, 1995).

CS can form a semi-permeable coating that can modify the internal atmosphere, thereby decreasing transpiration rates in food products (Nisperos *et al.*, 1994). Relative to commercial polymers, edible CS films were extremely good barriers to permeation of oxygen, while exhibiting relatively low water vapor barrier characteristics (Butler *et al.*, 1996). Acetic acid often has been the solvent for the production of CS films.

The objective of this study was to measure the viscosity of several combinations of SS and CS blends over the same temperature range in an attempt to produce SS/CS blends with optimum viscosity.

Materials and Methods

The sago starch powder was obtained from Wee Kwong Sendirian Berhad Sarawak Malaysia. Different concentrations of SS solutions were prepared. 0.1 mol of starch (on a repeat unit basis i.e. 16.2g) (Ambuj *et al.*, 1995) dissolve in 500 ml distilled water yield a 0.2M SS solution. 0.24M, 0.28M, 0.32M SS solutions were also prepared using 0.12, 0.14, 0.16 mol of starch respectively dissolve in 500 ml distilled water. The ratio by percentage of dry weight of SS to CS blends prepared was 90/10, 80/20, 70/30, 60/40 and 50/50. A typical procedure for preparing the blends is as the following. 90/10 SS/CS (90%SS and 10%CS) blend was prepared by dispersing 4.5g (90% w/w) SS in 250 ml distilled water (giving 0.1M SS solution) while stirring on a magnetic stirrer/hot plate up to 80°C. The SS solution is left to cool down to room temperature. CS solution was produced with 5g (10% w/w) CS in 250 ml 0.5M acetic acid and left for 3 hours. The blend solution is prepared by mixing both SS and CS solutions and left for 1 hour.

Viscosity of pure SS, pure CS and SS/CS blends with different ratios were studied using Brookefield Digital Viscometer Model DV-II Version 2.0. The DV-II viscometer measure fluid parameters of shear stress and viscosity at given shear rates. Viscosity is a measure of a fluid's resistance to flow. The principle of operation of the DV-II is to drive a spindle (which is immersed in the test fluid) through a calibrated spring. The viscous drag of the fluid against the spindle is measured by the spring deflection. The viscometer was calibrated using viscosity standard fluid 9306 and 4850 centipoise (cP) and the accuracy was ±1% respectively. The viscosity measurements were read for every

Table 1: Mean Viscosity and Temperature for Various Solutions of Sago Starch and Pure Chitosan

Temperature	Viscosity				
(Celcius)	0.2M	0.24M	0.28M	0.32M	chitosan
30	21.0	275	74.5	110.1	23.0
35	21.0	276	81.0	110.1	20.0
40	21.0	277	74.0	101.4	16.2
45	20.8	276	72.0	95.4	15.9
50	20.8	274	67.0	95.1	15.7
55	20.6	271	65.5	94.5	15.5
60	20.6	268	64.0	94.2	13.2
65	20.6	266	64.5	93.9	12.0
70	20.6	240	144.0	96.0	11.9
75	20.8	237	165.5	114.6	11.9
80	23.4	225	140.5	181.8	11.5
85	24.2	179	131.5	196.5	10.8
90	24.0	146	122.0	173.4	10.0
95	23.6	146	115.0	150.0	10.0

Table 2: Mean Viscosity and Temperature for Various Sago Starch/Chitosan Blends, Pure CS and Pure SS

Temperature	Sago starch/chitosan blends						
(Celcius)	50SS/50CS	60SS/40CS	70SS/30CS	80SS/20CS	90SS/10CS	100CS	100SS
30	39.4	30.1	25.0	21.8	18.9	23.0	21.0
35	36.6	27.2	22.3	20.5	17.9	20.0	21.0
40	33.3	24.9	20.6	19.5	16.4	16.2	21.0
45	30.5	22.7	18.9	18.9	15.6	15.9	20.8
50	26.1	21.7	17.6	18.3	15.4	15.7	20.8
55	24.4	20.1	16.4	15.0	15.2	15.5	20.6
60	17.6	18.9	15.0	14.8	14.2	13.2	20.6
65	17.5	18.3	14.3	14.6	13.7	12.0	20.6
70	17.4	16.6	14.1	14.2	13.3	11.9	20.6
75	21.0	14.9	13.0	14.0	12.5	11.9	20.8
80	18.8	13.7	10.9	13.5	12.3	11.5	23.4
85	17.5	13.6	10.7	13.4	12.2	10.8	24.2
90	19.1	12.7	10.5	13.3	12.0	10.0	24.0
95	13.1	10.9	10.3	12.8	11.1	10.0	23.6

interval of 5°C increment. All measurements were done using spindle SP61 at a speed of 60 rotations per minute.

Results and Discussion

Before blending the solution of SS and CS, preliminary viscosity measurement was made on different concentration of SS solution. To avoid confusion on the effect of concentration of SS solution on the SS/CS blend, the viscosity of different concentration of SS solutions were plotted with temperature. The range of values measured for each concentration of SS solution and SS/CS blend composition and their calculated mean values for the various solutions and blends were compared (Tables 1 and 2). Fig. 1 showed the viscosity versus temperature for all the different concentration of SS solution together with pure CS solution.

Fig. 1 obviously showed the inconsistency of the viscosity of SS with temperature except for 0.2M SS. As the SS concentration increases to 0.24M, the viscosity at 30°C increased drastically from 21 to 275 cP. As the concentration increase further to 0.28M the

viscosity at 30°C drop to 74.5 cP but surprisingly increase again to 110 cP at 0.32M. Although the initial viscosity of 0.24M SS solution (275 cP) is 10 times higher than the 0.2M SS solution (21 cP) the effects of temperature upon the viscosity of 0.24M SS solution is very significant especially above 70°C. The slight increase of initial viscosity of 0.28M and 0.32M SS solutions i.e. 74.5 cP and 110 cP respectively might create doubt on the viscosity of SS/CS blends. From

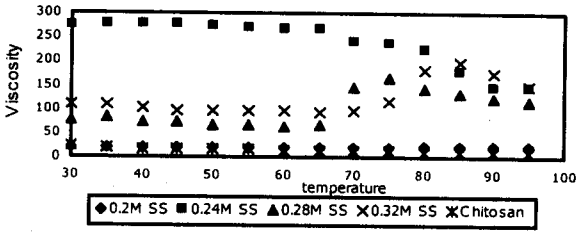

Fig. 1: Viscosity vs Temperature for 0.2M, 0.24M, 0.28M,0.32M Sago Starch and Pure Chitosan

Fig. 1 it is decided to produce the SS/CS blend using SS solution less than 0.2M based on the consistency and similarity of 0.2M SS solution and pure CS solution with temperature.

Fig. 2 shows the viscosity versus temperature for 90/10, 80/20, 70/30, 60/40 and 50/50 SS/CS blends. Also included in Fig. 2 are pure SS and pure CS solutions. Fig. 2 showed that the 50/50 blends yield the highest viscosity that indicates strong compatibility between the two solutions. As SS increase (60/40 and 70/30) the viscosity drop accordingly approaching pure CS solution. 80/20 and 90/10 blends yield poor compatibility with values of viscosity lower than pure SS and pure CS. As the temperature increase, inconsistency occurs above 60°C for 50/50 blends. This may be due to the CS content that is also shown in pure CS solution. The viscosity of SS solution is quite constant except above 75°C.

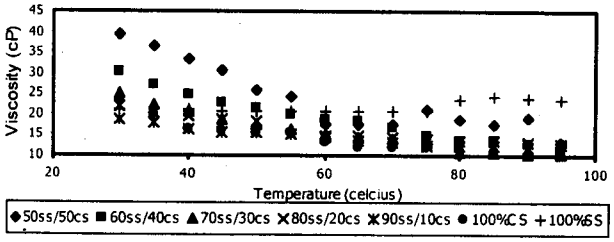

Fig. 2: Viscosity vs Temperature for Pure SS, pure CS and Blends of SS/CS

A significant conclusion made from Fig. 2 is that a compatible blend that yields the highest viscosity is obviously from the 50/50 blends. The results also suggest that although the 50/50 blends yield the highest viscosity at room temperature the effect of increasing temperature on the blends reduce the viscosity drastically compared with other blends. A decrease in viscosity with temperature indicates that the blends are becoming relatively more viscous in nature with rising temperature.

The blend containing 50%CS was superior compared to other blends and this finding is consistent with earlier works on compatibility studies of polypropylene/sago starch blend using DMTA (Hamdan *et al.*, 2000). The reason that the 50% blend has higher viscosity than other SS/CS blends is due to the higher content of CS that yields more miscible blend.

Conclusion

Increasing CS concentrations had a positive effect on the viscosity of SS/CS blend but at elevated temperature the higher CS content contribute to drastic changes in the viscosity compared with other blends. At room temperature the CS content in SS/CS blend increases the viscosity accordingly. At elevated temperature inconsistency of viscosity changes with temperature is attributed to the CS content as shown by pure CS solutions.

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