

Use of Chitosan Adhesive for the Manufacture of Corrugated Fibreboard

T.K. Srinivasa Gopal, R. Thankamma, K.G. Ramachandran Nair,
P.V. Prabhu and P. Madhavan

*Central Institute of Fisheries Technology
Kochi - 682 029*

Peeling strength of kraft paper-kraft paper and kraft paper- corrugated fibreboard (CFB) bonded using 1.5% chitosan in 1% acetic acid of viscosities 20, 130 and 500 cp and starch were compared. The peeling strength between kraft paper-kraft paper and kraft paper-corrugated fibreboard was same in both starch and chitosan (1.5% and 130 cp viscosity) adhesive. The frozen storage behaviours of 5 ply corrugated fibre board prepared using 1.5% chitosan of viscosity 130 cp and starch solution having 10% solids were studied. The bursting strength, puncture resistance and flat crush strength were reduced during storage, but the amount of reduction was more in CFB using starch based adhesive. The starch based adhesive board delaminated on immersion in water while chitosan based adhesive board did not delaminate. CFB using chitosan adhesive had more compression strength than the starch adhesive CFB.

The adhesive represents 1 to 2% of the total cost of the corrugated board. It can be the weakest link in a long chain if it is not correctly prepared and applied. The complex and expensive machinery for the manufacture of corrugated fibreboard can never function efficiently unless the adhesive is properly formulated and correctly used. Often the lack of a basic understanding of the adhesive and optimum operating condition required can lead to wastage of production time and poor board quality. In India the 2 ply boards are made by machine pasting at high temperatures while 3 ply and 5 ply boards are generally made by hand pasting at room temperature. The pasted boards are kept under pressure and allowed to dry. The adhesive that is commonly used for the manufacture of corrugated board is starch and has remained as the predominant corrugating adhesive. The main defects reported in the master carton used for the export of marine products from India are low mechanical strength and tendency to get wet (Gopal & Govindan, 1980). Often there will be

water absorption by the starch adhesive. When the corrugated board is subjected to high humidity or even water, a wet strength adhesive should be used (Murthy, 1972). These are normally formulated by incorporating resins such as urea formaldehyde, ketone formaldehyde and resorcinol formaldehyde along with the starch adhesive. This paper deals with the use of an alternative adhesive based on chitosan, its effect on the peeling strength, the effect of frozen storage on the properties of corrugated fibreboard and a comparison with that prepared out of starch adhesive.

Materials and Methods

The adhesives used in the experiments were 1.5% solution (in 1% acetic acid) of chitosan of varying viscosities (20, 130 and 500 cp when measured in 1% solution in 1% acetic acid) and a solution of starch in water (10% solids) which is generally used by CFB manufacturing industry. 120 GSM kraft paper and 5 ply CFB obtained from the industry were used in the experiments for studying the physical properties. The

test specimen for determination of peeling strength of the adhesives were prepared as per ASTM (1972) by bonding paper to paper and paper to CFB. The pasted boards were kept over night for drying by applying a pressure of 0.25 kg/cm^2 by keeping known weights. The samples were conditioned before testing by the method described in IS : 1060 (1966). Peeling strength of the kraft paper was determined using Zwick universal testing machine as per ASTM (1972).

Suitability of chitosan in the manufacture of corrugated fibreboard was tested in the field condition in a factory making corrugated fibreboard. The two ply was first prepared by using starch adhesive and subsequently 5 ply corrugated fibreboard was prepared from 2 ply CFB by using 1.5% chitosan of 130 cp viscosity in 1% acetic acid as the adhesive. 5 ply corrugated fibreboard was also prepared using starch adhesive out of 120 GSM recycled kraft paper. The physical properties of the boards were studied after conditioning the samples by the method described in IS : 1060 (1966). Moisture was determined by drying the sample in an oven at 100°C till constant weight. Bursting strength and water proofness expressed in terms of cobb 30' value was determined as per the above standard. Puncture resistance was determined according to IS : 4006 (1972). Flat crush strength was determined by the method described by Indian Institute of Packaging, Bombay (Anon, 1973). Compression strength of the box made out of 5 ply CFB using both chitosan and starch adhesives was determined as per ASTM (1973). 5 ply corrugated fibreboard boxes in the prepared flat condition were kept in frozen storage after conditioning as per IS : 1060 (1966) and kept at -20°C for 5 months. Periodically the samples were removed from the frozen storage and analysed for various parameters like moisture uptake, bursting

strength, puncture resistance and flat crush strength.

Results and Discussion

Peeling strengths of the kraft paper using 1.5% chitosan (in 1% acetic acid) adhesive of viscosities 20, 130 and 500 cp compared with starch adhesive are reported in Table 1. It was found that the peeling strength between kraft paper-kraft paper and kraft paper-corrugated fibreboards using 1.5% chitosan adhesive of viscosity 130 cp was same as that of the starch adhesive having 10% solids. The peeling strength was greater in case of chitosan adhesive having viscosity 500 cp. Lower viscosity chitosan adhesive (20 cp) gave lower peeling strength. Since 1.5% chitosan of 130 cp gave the same peeling strength as that of starch adhesive containing 10% solids, all the experiments related to the manufacture of corrugated fibreboard and frozen storage characteristics were done with 1.5% chitosan of 130 cp.

Table 1. *Peeling strength of kraft paper-kraft paper, kraft paper- corrugated fibreboard using chitosan adhesive of different viscosities and starch*

Details	Peeling strength N/mm			
	Paper-board		Paper-paper	
	MD	CD	MD	CD
Starch (10% solids)	0.324	0.208	0.114	0.094
Chitosan 20 cp	0.265	0.192	0.082	0.059
Chitosan, 130 cp	0.329	0.222	0.113	0.100
Chitosan, 500 cp	0.490	0.257	0.130	0.110

MD - Machine direction; CD - Cross direction

Table 2 gives the physical properties of 5 ply corrugated fibreboard prepared out of chitosan adhesive and starch. Chitosan adhesive board possessed higher puncture resistance, flat crush strength and compres-

Table 2. *Physical properties of 5 ply corrugated fibreboard made out of 120 GSM recycled kraft paper using chitosan adhesive and starch based adhesive*

Details	Chitosan board	Starch board
Bursting strength, kg/cm ²	9	9
Puncture resistance, beach units	170	150
Flat crush, N/cm ²	13.02	12.48
Cobb 30' value	116	135

sion strength. This might be due to overall improvement in the properties of kraft paper due to chitosan. Considerable improvements in the properties was reported in the kraft paper coated with chitosan solution (Gopal *et al.*, 1981). The load deformation curve of corrugated fibreboard boxes prepared out of chitosan adhesive and starch adhesive are shown in Fig. 1. CFB made out of chitosan adhesive was having more compression strength than the starch adhesive. It required more deformation displacement to reach the maximum load for

the first buckling to occur in the compression strength tester. Similarly the work done on the box was more on the chitosan adhesive CFB than the starch board. Since the compression strength was higher for boxes made of chitosan adhesive CFB, more boxes could be stacked in the frozen storage.

Table 3 gives the changes in physical properties of corrugated fibreboard cartons of chitosan adhesive and starch adhesive during frozen storage for 5 months. An increase in moisture content was observed after 3 1/2 months storage in both starch based adhesive CFB board and chitosan adhesive board. After 3 months the moisture content in the starch based adhesive board was around 17% whereas in the case of chitosan adhesive board it was 12%. There was a reduction in the bursting strength, puncture resistance and flat crush strength during frozen storage in starch based adhesive CFB and chitosan based adhesive CFB. But the amount of reduction in strength properties was more in starch based adhesive CFB than chitosan adhesive CFB. The uptake of moisture might be the reason for the reduction of strength properties. The starch based adhesive board got delaminated after immersion in water. It

Figure. 1

Load - deformation curve 5ply corrugated fibre board box (CFB) of the size 350 mm x 270 mm x 160 mm prepared using chitosan adhesive (1) and starch based adhesive (2).

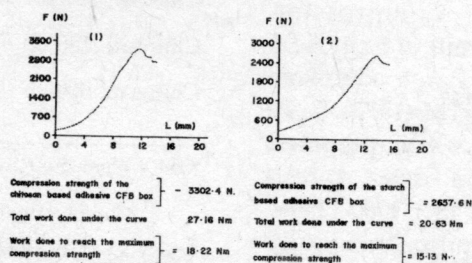


Fig. 1 Load - deformation curve 5ply corrugated fibre board box (CFB) of the size 350mm x 270mm x 160mm prepared using chitosan adhesive (1) and starch based adhesive (2)

Table 3. *Effect of frozen storage on the properties of 5 ply corrugated fibreboard using chitosan adhesive and starch adhesive*

Period of storage, months	5 ply CFB board using starch adhesive				5 ply CFB board using chitosan adhesive			
	Moisture %	Bursting strength kg/cm ²	Puncture resistance beach units	Flat crush N/cm ²	Moisture %	Bursting strength kg/cm ²	Puncture resistance beach units	Flat crush N/cm ²
0	5.52	9	150	12.48	6.02	9	170	13.02
1.5	5.60	9	150	12.48	6.10	9	170	13.02
3	9.13	8	140	8.30	7.70	8.5	150	8.70
5	17.00	8	120	6.75	12.00	8.5	130	7.02

was very difficult to delaminate chitosan adhesive board under the same condition.

From the above results it is concluded that chitosan adhesive corrugated fibreboard is an ideal substitute for starch based adhesive for the export of frozen shrimp. In the starch based adhesive, chemicals like urea formaldehyde, ketone formaldehyde or resorcinol formaldehyde is to be added to give sufficient wet strength whereas chitosan, a natural polymer, gives the same properties. As there is no delamination of plies in the corrugated fibreboard coated with chitosan adhesive even in the presence of water and gives better strength properties and storage characteristics, chitosan adhesive board is a good substitute for starch based adhesive board. Wet strength and improvements in the strength properties of chitosan adhesive makes it suitable in the manufacture of CFB.

The authors are grateful to the Director, Central Institute of Fisheries Technology, Kochi-29 for his kind permission to publish this paper and to M/s Industrial Packagings, Kochi for providing facilities to conduct field experiments.

References

- Anon (1973) *Paper and Paper Board in Packaging*. Indian Institute of Packaging, Bombay, p.125
- ASTM (1972) *Standard Method of Test for Peel or Stripping Strength of Adhesive Boards*, D903-49, American Society for Testing and Materials, Philadelphia, U.S.A.
- ASTM (1973) *Standard Method of Compression Test for Shipping Containers*, D642-47 (reapproval 1973) American Society for Testing and Materials, Philadelphia, U.A.A.
- Gopal, T.K.S. & Govindan, T.K. (1980) *Fish. Technol.* 17, 103
- Gopal, T.K.S., Ramachandran Nair, K.G., Thankappan, T.K. & Govindan, T.K. (1981) *Perf. Pack. J.* 21, (8 & 9), 5
- IS:1060 (1966) *Methods of Sampling and Test for Paper and Allied Products*; Part I, Indian Standards Institution, New Delhi
- IS:4006 (1972) *Methods of Test for Paper and Pulp Based Packaging Materials*, Part II. Indian Standards Institution, New Delhi
- Murthy, H.B.N. (1972) *Adhesive for Corrugated Board Industry*. Presented in the All India Corrugated Manufacturer's Conference held in Bombay organised by Federation of Corrugated Box Manufacturer's Association, Bombay