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FUTURE OF FOOD PACKAGING INDUSTRY WITH NEW GENERATION BIO-POLYMER



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Abstract :

Due to fast change in life style, food packaging sector is growing rapidly in recent years. Since the Food is precious, packaging become very important to reach to customer in a good and hygiene conditions without any contaminations from external environment and packaging itself. Focusing on recent trends in food packaging by Indian Food Tech startups, the food packaging becomes a key point. The hot food is packaged and served in plastic containers, hot food reacts with plastic (one of the example if such plastic, Polystyrene foam) and causes 52 different types of cancers as per one of the study in USA. Currently most of the Food Tech startups are packing the hot food in plastic containers, which is unsafe and may cause serious health issues in future.

This concern is our motivation to start investigation on safe and hygiene packaging solution for food packaging. A bio-polymer, which is antimicrobial in nature and polymer by property, has been identified to be effective in pulp & paper making as a wet end additive and/or Surface sizing chemical to impart Anti-bacterial, Anti-fungal and water resistance property for output packaging product. The bio-polymer which is selected for the study is a natural occurring polysaccharide and has wide acceptance over many fields like health care products, agricultural bio pesticide products and in other industries too.

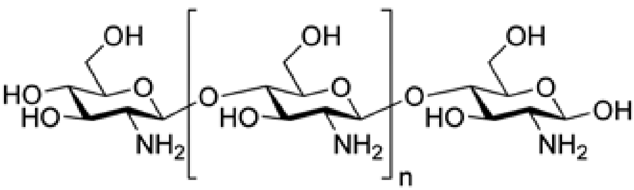
This paper highlights in detail the application of bio-polymer solution as a barrier coating on kraft paper. Application of bio-polymer film on the surface of kraft paper not only provides efficient oxygen barrier by lowering the air permeability & water absorption capacity (Cobb) but also improves mechanical properties (tensile strength, tearing strength, bursting strength, double fold and bending stiffness) of paper. This paper also compares the test results (mechanical properties) of bio polymer solution against cationic starch application as a barrier coating on kraft paper. This comparison will prove the value addition of bio polymer solution application as a barrier coating on kraft paper against conventional cationic starch solution application as a barrier coating on kraft paper.

INTRODUCTION

Quest started to find out a special packaging paper for food and pharmaceutical packaging, first thought came into mind was "WASABI", a Japanese food item, which is anti-microbial in nature. Japanese food parcel package contains WASABI, which is used both as a food item (generally used with SUSHI) and anti-microbial agent*1. Most of the high-end hotels and restaurants use WASABI as a dish and anti-microbial agent to preserve the food. Anti-microbial property of a WASABI not so explored. However, due to non-availability or shortage of WASABI in India, then tried find a biodegradable and food grade compound. We come across some of the literatures on Chitosan*2 being tried as surface sizing on kraft paper. It looks little promising, later it's been further explored to availability of chitosan in India for commercial production. We found that there is a huge association*3 available for chitin and chitosan, to promote the chitosan usages in different areas of applications.

Chitosan is a linear polysaccharide composed of randomly distributed β-(1→4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It is made by treating the chitin shells of shrimp and other crustaceans with an alkaline substance, like sodium hydroxide.

Chitosan has several commercial and possible biomedical uses. It can be used in agriculture as a seed treatment and bio-pesticide, helping plants to fight off fungal infections. In winemaking, it can be used as a fining agent, also helping to prevent spoilage. In industry, it can be used in a self-healing polyurethane paint coating. In medicine, it may be useful in bandages to reduce bleeding and as an antibacterial agent; it can also be used to help deliver drugs through the skin. *4



Later, to understand the literature contents, application of Chitosan as Wet end additive and as Surface sizing agent on kraft paper was explored at CPPRI, Saharanpur laboratory through series of experiments.

Experiments

The studies were conducted on IOCC furnish to assess the efficacy of Chitosan on improving the physical mechanical properties of kraft paper. In the present investigation, three approaches were selected.

First approach involved application of chitosan solution as surface sizing agent. Selected OCC furnish was slushed in hydropulper at 12% consistency and ambient temperature. The slushed pulp was further screened through 0.15 mm slot Somerville Laboratory screen. 90 gsm hand sheets were prepared using British hand sheet former. The hand sheets were surface sized with 10 gpl chitosan solution in laboratory size press and further dried in rapid dryer for 2-3 minutes at 230^0F.

In the second approach, chitosan solution was added in OCC pulp stock at a dosage level of 8 kg/t and 90 gsm hand sheets were made.

In the third approach, chitosan solution at a dose level of 8 kg/t was added at wet end followed by surface sizing with 10 gpl chitosan solution.

A parallel study was also conducted using cationic starch, commercially used by paper industry. Similar approach has been taken while using cationic starch for comparing the results with chitosan. In case of cationic starch, dose of 4 kg/t was added at wet end and hand sheets were surface sized with 70 gpl cationic starch solution.

Following physical mechanical properties were evaluated on the hand sheets.

- **(i) Zero Span Tensile Strength (Fiber Strength) -** The Zero Span Tensile Strength (ZSTS) value is reported in km. This test measures the intrinsic strength of individual fiber and provides a possibility to measure the fiber strength separated from other effects. It is a good indicator of the average strength of individual fiber.
- **(ii) Cobb value -** Water absorptiveness (cobb value) is resistance of paper towards the penetration of aqueous solution / water.
- **(iii) Bending stiffness -** It is a measure of the resistance offered to a bending force by a rectangular sample, expressed in mN (milli Newton).
- **(iv) Tensile strength -** Tensile strength is the maximum force per unit width that a paper strip can resist before breaking when applied longitudinally. It depends on fiber strength but primarily on the degree of bonding between areas.
- **(v) Tearing strength -** Tear strength is the mean force required to continue the tearing of paper from an initial cut. Highly dependent on fiber orientation of sheet and affects run ability. Longer and stronger fibre provides high tearing strength.
- **(vi) Bursting strength -** It is an important property for packaging grades of paper and paperboard and is an indicator of sheet bonding. Bursting strength is the maximum pressure that paper can resist without breaking when force is applied perpendicular to the plane. Increase fiber length gives higher bursting strength but is more affected by fiber bonding. It is predominantly an internal sheet property.
- **(vii) Anti Microbial test -** The Anti-microbial test was conducted as per the standards (Gram-negative bacteria Escherichia coli (ATCC 11775)).

Results and Discussion

1. Characterization of Polysaccharides

Table-1 summaries the characteristics of polysaccharides used in the present study with respect to surface charge measure as Zeta Potential (mV) and pH.

Table-1 : Characterization of Polysaccharides

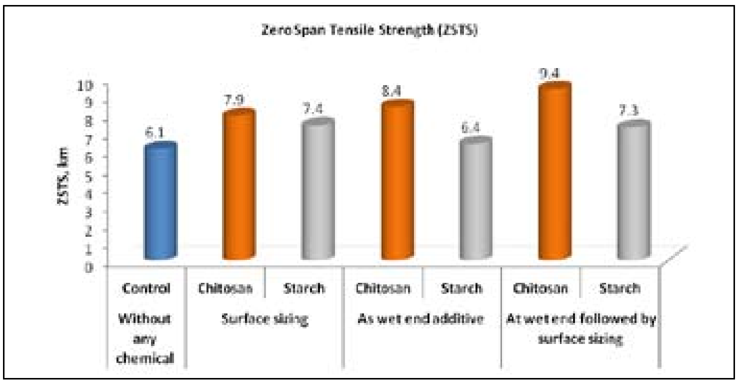
Particular	**Chitosan Soln. (10 gpl)**	**Starch Soln. (70 gpl)**
pH	4.4	7.6
Surface Charge, mV	(+) 248	(+) 46
Charge Demand, µeq/g	262	53

Both the polysaccharides are cationic in nature; however, the chitosan solution is more cationic in nature. The pH of Cationic starch solution is in neutral range whereas chitosan solution is acidic in nature.

2. Comparative Performance of Polysaccharides towards Physical Strength Improvement

Each test was performed in 3 X 3 combinations, i.e. without any chemical, with chitosan solution (10gpl) and with starch solution (70gpl), and used as a Surface Sizing agent (SS), as wet end additive (WE) and in wet end followed by Surface sizing (WESS). Considering three results of control case as base line result, for each test, 7 results have been compiled.

i. Zero Span Tensile Strength (ZSTS)



Experiment shows that performance of chitosan in improving the ZSTS value is far better than cationic starch. Chitosan performed best in improving the ZSTS value when used at WESS (6.1 km to 6.4 km).

The ZSTS value increased by 30%, 38% & 54% with chitosan at SS, WE and WESS respectively. The starch has shown maximum improvement of 21% only with surface sizing. Thus, showing chitosan is more effective than starch in improving the individual fiber strength.

ii. COBB$_{60}$

Chitosan has shown best performance (COBB$_{60}$ value- 22 gsm) during SS alone as compared to when used as WE or WESS.

The Cobb value improved by 90%, 60% & 89% when OCC furnish is treated with chitosan at SS, WE, WESS respectively. The starch has shown maximum improvement to the tune of 22-23% with SS and WESS respectively. This implies that chitosan is suitable for barrier coating as compared to starch.

iii. Bending stiffness

Result shows that chitosan is more effective than starch in improving resistance offered to a bending force. Maximum bending stiffness achieved is 11.5 mN when OCC furnish is treated with chiotsan at WESS. Similar trend was observed when chitosan is used as SS agent alone.

The bending stiffness value increased by 47%, 20% & 53% with chitosan at SS, WE and WESS respectively. The starch has shown maximum improvement of 33% at WESS.

iv. Tensile strength

The result shows that chitosan is more effective than starch in improving resistance before breaking. Tensile strength is increased by double fold (2206 N/m to 4570 N/m) when chitosan is used at WESS.

The Tensile strength value increased by 63%, 78% & 107% with chitosan at SS, WE and WESS respectively, whereas, starch has shown maximum improvement of 42% when hand sheets are surface sized.

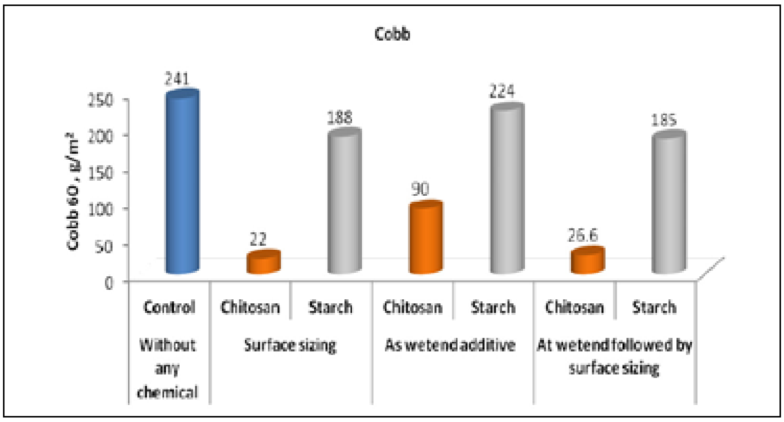
v. Tearing strength

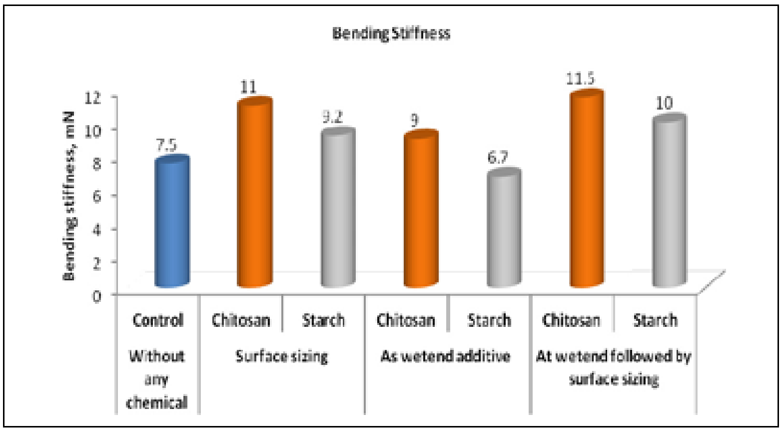
Result shows that chitosan is more effective than cationic starch when used during SS.

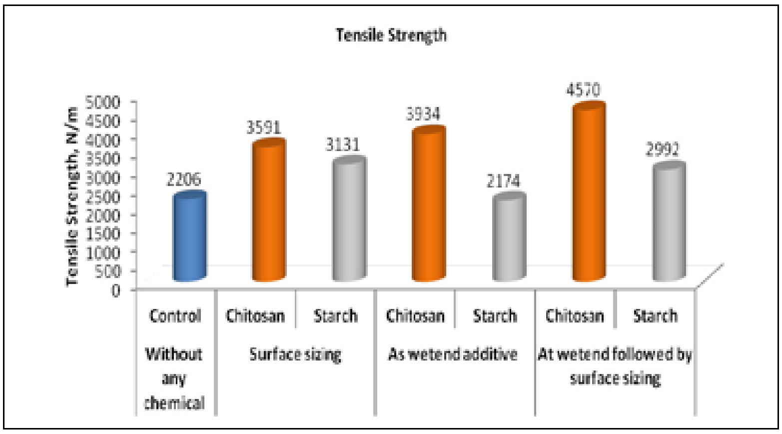
Chitosan has shown improvement in tearing resistance to the tune of 12%, when hand sheets are SS. whereas; starch has shown maximum improvement of 7% at WESS.

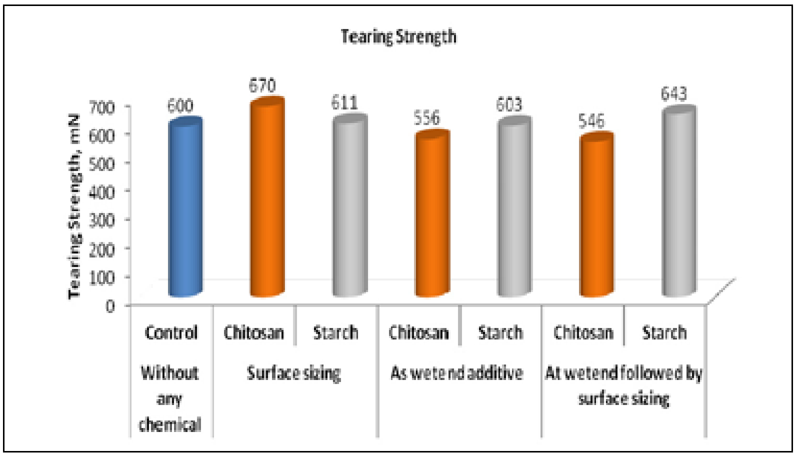
vi. Bursting strength

Cationic starch has shown maximum efficacy towards increasing in bursting strength (125 kPa to 290 kPa) when used at SS alone.







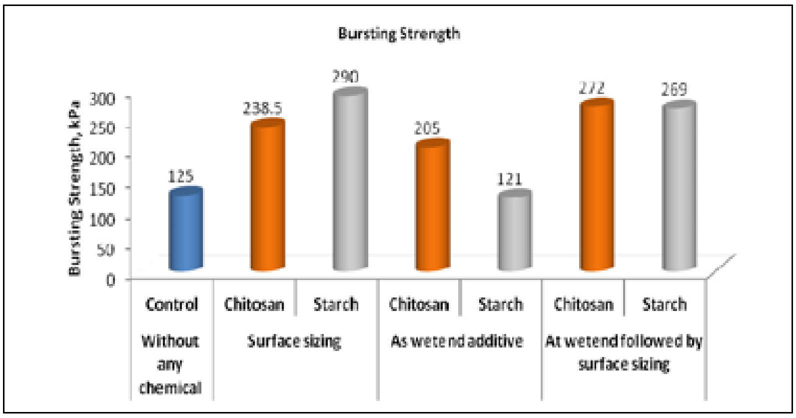


Result shows that chitosan is more effective than cationic starch wher

The Bursting strength value increased by 91%, 64% & 118% when chitosan is used at SS, WE, WESS respectively. However, cationic starch has shown an improvement of 132%, -3% & 115% when treated in similar sequence as above.

vii. Anti-microbial test

This is performed 45 days by developing the bacterial colonies on chitosan solution. The colonies are not developed, therefore its evident that chitosan solution is anti-microbial in nature. This test is also performed by using the BACTASLYDE test kit. In the next stage, trying to develop colonies on chitosan applicated paper. There were some reference where its been proved that chitosan applicated paper also anti-microbial for some period of time.



Conclusion

For better understanding the results, all the seven results of each test have been compared in a same plane, in three categories i.e. SS, WE and WESS. For simple understanding the symbol system has been introduced, to show how the chitosan results compared to starch and control results.

✌ **Small or not much improvements over starch and control results**

👍 **Great improvement over starch and control results**

1. The summary of Chitosan result as Surface sizing agent is shown in the below table. Chitosan solution as a surface sizing agent improves all the mechanical and physical properties of Kraft paper compared to control and with starch results.

Test Parameter	Surface Sizing
Zero Span Tensile Strength (ZSTS) (km)	👍
Bending stiffness (mN)	👍
Cobb (60)	👍
Tensile strength (N/m)	👍
Tearing strength (mN)	👍
Bursting strength (kPa)	✌
Anti-microbial test	👍

2. The summary of chitosan result as Wet end additive is shown in the below table. chitosan solution at Wet end additive improves all the mechanical and physical properties of Kraft paper compared no chemical and with starch results.

Test Parameter	Wet End Additive
Zero Span Tensile Strength (ZSTS) (km)	👍
Bending stiffness (mN)	👍
Cobb (60)	👍
Tensile strength (N/m)	👍
Tearing strength (mN)	✌
Bursting strength (kPa)	👍
Anti-microbial test	👍

3. The summary of Chitosan result as Wet end additive followed by surface sizing agent is shown in the below table. Chitosan solution at Wet end additive followed by surface sizing agent improves all the mechanical and physical properties of Kraft paper compared no chemical and with starch results.

It is estimated 8 Kg of chitosan and 4 Kg of starch is required at Wet end. Cost per ton, chitosan solution is 100 INR and cost per ton, starch is 30 INR. The difference amount is 70 INR, which is paid for much more improvement over starch results, especially Cobb and anti-microbial properties.

3.

Test Parameter	Wet End followed by Surface Sizing
Zero Span Tensile Strength (ZSTS) (km)	👍
Bending stiffness (mN)	👍
Cobb (60)	👍
Tensile strength (N/m)	👍
Tearing strength (mN)	✌
Bursting strength (kPa)	👍
Anti-microbial test	👍

4. During surface sizing an improvement in GSM by 3.15 g/m2 was observed when chitosan is use, whereas starch has shown an improvement of 2.95 g/m2.

5. Chitosan solution application on Kraft paper, improves the quality of packaging for Food and Pharma further more as our motivation of investigation is fulfilled.

6. Due to its cationic behavior chitosan is more effective in improving the fines retention as well as helps in reducing the anionic trash in back water.

7. Chitosan solution servers the purpose of more than 2-3 chemicals normally used in paper industry and most important is, it's Biodegradable and nontoxic solution – "ECOFRIENDLY".

Future scope of the work

1. Patent filing process for commercial preparation process and application on kraft paper is under progress.

2. Commercial preparation of chitosan solution has been started and trials in paper mills are planned.

3. There are many other applications in paper, to further explore the usage of chitosan, studies on making hygiene tissue paper, antibacterial coated low gsm wrapping paper for food sector and application of anti-microbial coating on metallic surfaces of paper machineries is in progress.

References

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*3: ICCS: Indian Chitin and Chitosan Society: www.inchis.org

*4: two paragraphs, above from this notation are extracted from Wikipedia.com