JOURNAL REVIEW: ANALYSIS OF ALTERNATIVE WET STRENGTH AGENT MATERIALS AS AN EFFORT TO INCREASE PAPER RESISTANCE IN WET CONDITIONS

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Abstract

The demand to win the competition and be able to create quality products in the industrial world, especially the paper industry. Making paper factories compete to produce superior products that satisfy consumers, especially the durability of paper in wet conditions. Wet Strength Agent is a chemical added to the paper making process. Some paper industries still use conventional resins, including formaldehyde derivative resins, epichlorohydrin polyamide resins, and epoxide resins. However, these resins contain monomer groups which can damage the environment, are difficult to grade and are dangerous to health. Several researchers have found environmentally friendly alternative wet strength agents, including chitosan modified with anhydride, cationic starch, carrageenan, bentonite, or a mixture of carrageenan and bentonite. Based on the results obtained, this alternative material can increase the resistance of paper in wet conditions and can be used as an alternative wet strength agent in making paper, especially paper which is specifically able to withstand climate and weather.

Keywords: *wet strength agent, chitosan, cationic starch, carrageenan, bentonite.*

1. Introduction

The pulp and paper industry is one of the large and strategic industries in Indonesia, which also has quite good development. This is shown by the national capacity which continues to increase to reach 11.04 million for the pulp industry, and 16.6 million for the paper industry. The increasing need for paper in the world, especially in Indonesia, has made paper factories compete to create superior products that satisfy consumers, especially the paper's ability to survive in wet conditions. Based on this review, it is necessary to add a wet strength agent to the paper making process.

Wet strength agent is a chemical that functions to increase paper's resistance to wet conditions or resistance to humidity. However, many paper industries still use conventional resins to increase the resistance of paper to moisture. These conventional resins include formaldehyde derivative resins, epichlorohydrin polyamide resins, and epoxide resins. However, this resin has several disadvantages such as containing toxic monomers, being difficult to degrade, and PAE was recently proven to contribute to the emission of absorbable organic halogens (AOX) such as chlorine gas from paper mills and this will inevitably damage the surrounding environment and be dangerous for the health of living creatures (Sianggaran et al., 2022).

Several researchers have found alternative wet strength agents that are more environmentally friendly, including chitosan modified with anhydride, cationic starch, carrageenan, bentonite, or a mixture of carrageenan and bentonite.

2. Materials and Methods

Research using alternative materials that has been carried out includes chitosan modified with maleic anhydride, cationic starch, carrageenan, bentonite, or a mixture of carrageenan and bentonite.

The method that has been used as an alternative chitosan material modified with maleic anhydride and cationic starch is to mix the agent powder with certain variables when making the handsheet. The method used to use carrageenan, bentonite, or a mixture of carrageenan and bentonite is by dissolving the material using denim water at a certain temperature, time and stirring until it becomes a solution that is ready to be used.

3. Data Analysis Results and Discussion

3.1.Modified Chitosan With Anhydride Plus Cationic Starch

Variations of modified chitosan 0%, 0.1%, 0.3%, 0.5%, and 0.7%, adding 1% cationic starch to each variable. Variations can be seen in **Table 3.1.1.**

Table 3.1.1. Agent Dosage Variations

Code	Chemical Variations	
	Modified Chitosan (%)	Cationic Starch (%)
1A	0	0
1B	0,1	0
1C	0,3	0
1D	0,5	0
1E	0,7	0
2A	0	0,5
2B	0,1	0,5
2C	0,3	0,5
2D	0,5	0,5
2E	0,7	0,5
3A	0	1
3B	0,1	1
3C	0,3	1
3D	0,5	1
3E	0,7	1

3.1.1. Wet Tensile Index

The best results occurred at a dose of 1% cationic starch with the addition of 0.7% modified chitosan, namely 17.40 Nm/g. The more chitosan added, the more covalent bonds are formed so that the wet tensile strength increases.

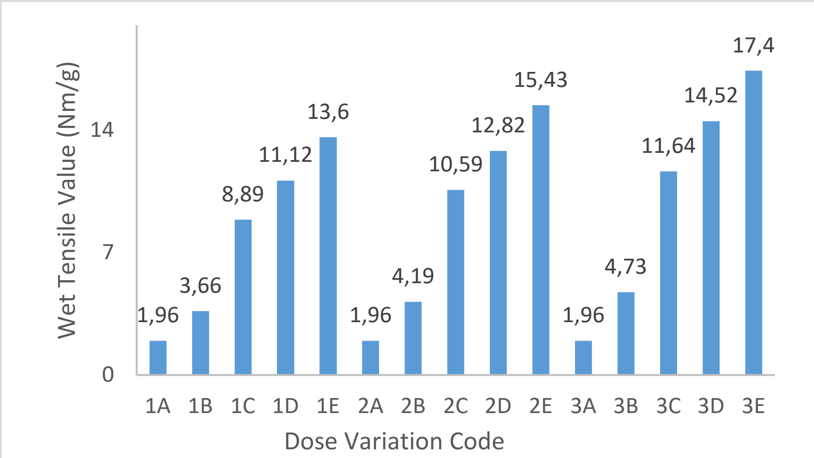

Figure 3.1. Wet Tensile Value Chart

3.1.2. Dry Tensile Index

The tensile index value increased by 65.14 Nm/g at a dose of 0.5% cationic starch and 72.46 Nm/g at a dose of 1% cationic starch. This happens because cationic starch is an additive that is often used as a dry strength additive in paper making to increase the tensile strength of paper. The highest value occurred at a dose of 1% cationic starch with the addition of 0.7% modified chitosan, namely 84.89 Nm/g. The increasing dose of cationic starch and modified chitosan will provide higher value, because the polymer material in cationic starch and modified chitosan can help maintain a tight bond between fibers, thereby helping the fibers to increase their tensile strength to a more optimal level (Basu et al., 2021).

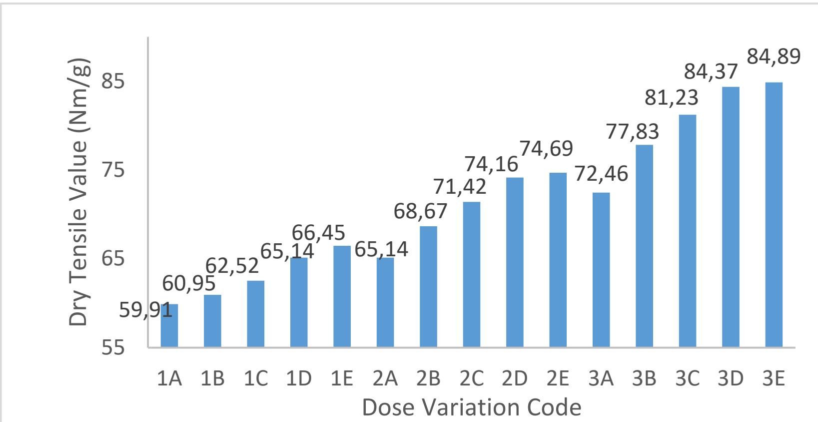

Figure 3.2. Dry Tensile Value Chart

3.1.3. Tensile Strength Ratio

Values that are above the quality standard start from a modified chitosan dose of 0.3% and 0% cationic starch. The optimal ratio value is found at a modified chitosan dose of 0.7% with the addition of 0.5% cationic starch of 20.67%. A decrease in the ratio value occurred when the dose of cationic starch was increased. Cationic starch can increase the dry strength significantly, but the wet strength increase is not very significant. This happens because the wet strength of cationic starch cannot stand alone in increasing the wetness index (Sianggaran et al., 2022).

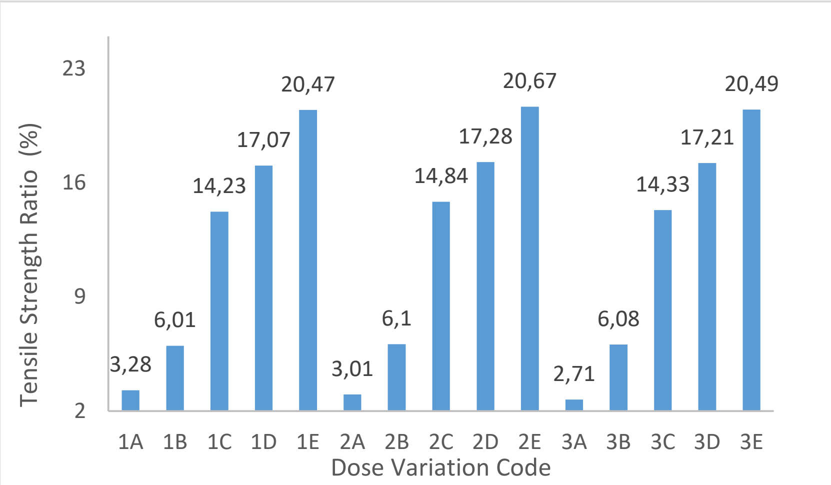

Figure 3.3. Tensile Strength Ratio Chart

3.1.4. Crack Index

This crack index shows similar results as the tensile index where the value is the highest occurred at a dose of 1% cationic starch with the addition of 0.7% modified chitosan, namely 7.14 kPa.m2/g. This happens because cationic starch is an additive that is often used as a dry strength additive in paper making to increase the dry strength of paper.

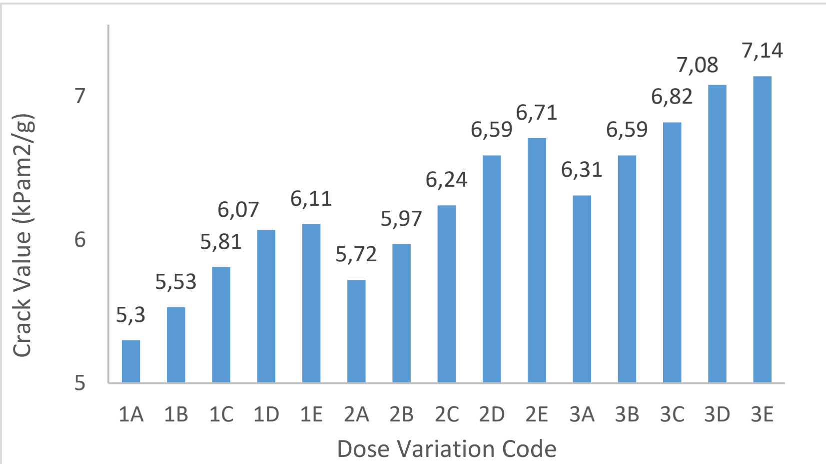

Figure 3.4. Crack Value Chart

3.1.5. Tear Index

The best value of the tear index, namely at a dose of 0.7% modified chitosan with the addition of 1% cationic starch, was 6.44 mNm2/g. This happens because the polymer material only plays a small role in increasing the tear index, the polymer will increase the strength value significantly in terms of tensile strength and rupture strength. Tear strength is significantly influenced by the number of fibers in the sheet, fiber length, degree of fibrillation and the number of bonds between fibers.

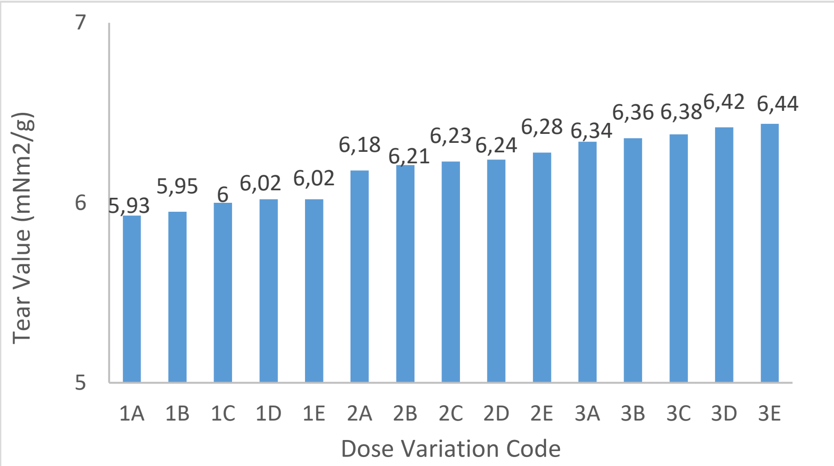

Figure 3.5. Tear Value Chart

3.1.6. Absorption Power Against Water

The optimum value of water absorption occurs at a modified chitosan dose of 0.7% with the addition of 1% cationic starch, namely 14.9 g/m2. The decrease in the water absorption value with the addition of modified chitosan can also have an effect, because the solution has a fairly high viscosity and will slow down the rate of water penetration after the sample becomes wet and this can occur because the formation of hydrogen bonds has reached equilibrium, as a result the water absorption from the sample is reduced (Sianggaran et al., 2022).

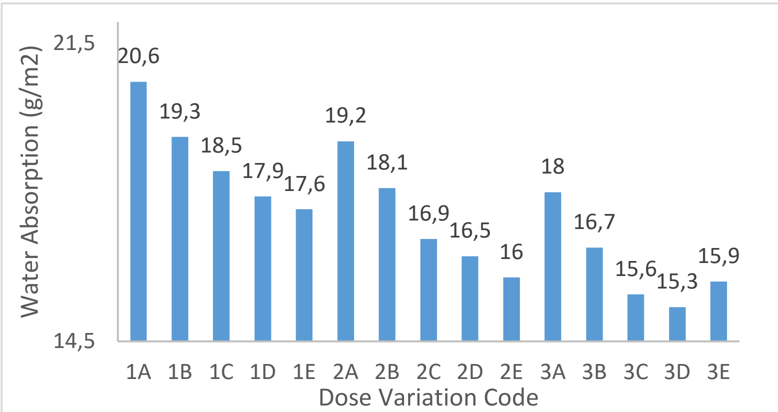

Figure 3.6. Water Absorption Chart

The best results were the right pH value in neutral conditions (pH = 7), achieving this neutral condition quickly at a dose of 1% cationic starch and the addition of 0.3% modified chitosan.

3.1.7. pH Surface Value

The best results were the right pH value in neutral conditions (pH = 7), achieving this neutral condition quickly at a dose of 1% cationic starch and the addition of 0.3% modified chitosan.

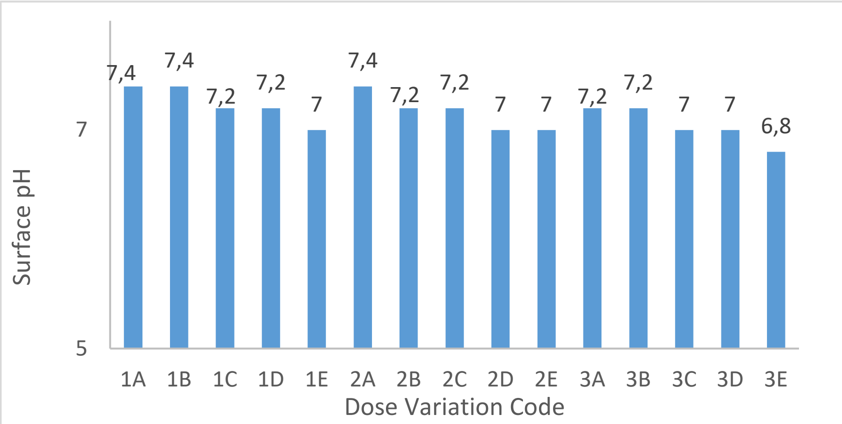

Figure 3.7. Surface pH Chart

Based on data from **Figure 3.7.** So this modified chitosan is good enough to be applied as an alternative additive.

3.2. Carrageenan

Experiments using Carrageenan obtained results that can be seen in **Table 3.2.1.**

Dose (Kg/T)	Dry Tensile (Nm/g)	Wet Tensile (Nm/g)	Tearing (mNm2/g)	Bursting (kPam2/g)	Bulky (cm3/g)
0	73,04	20,67	0,44	3,57	1,78
2,5	84,08	23,77	0,75	4,28	1,82
5	85,94	24,68	0,9	4,45	1,88
7,5	89,12	26,16	0,99	4,77	1,9
10	88,06	25,31	0,91	4,41	1,83

Table 3.2.1. Results of Adding Carrageenan as a Wet Strength Agent.

Based on the table above, it can be concluded that the highest results were found at the additional dose of carrageenan of 7.5 Kg/T, at a dose of 10 Kg/T there was a decrease because at this dose flocculation occurred, where polymer flocculation could interfere with the physical strength of the paper.

3.3. Bentonite

The following are the experimental results that have been obtained using Bentonite as a wet strength agent, where the results obtained can be seen in **Table 3.3.1.**

Dose (Kg/T)	Dry Tensile (Nm/g)	Wet Tensile (Nm/g)	Tearing (mNm2/g)	Bursting (kPam2/g)	Bulky (cm3/g)
0	73,04	20,67	0,44	3,57	1,78
2,5	82,6	24,28	0,74	4,3	1,83
5	85,84	25,68	0,85	4,42	1,87
7,5	84,5	24,75	0,77	4,26	1,85
10	83,96	23,16	0,72	4,13	1,86

Table 3.3.1. Results of Adding Bentonite as a Wet Strength Agent.

The highest value obtained was at a Bentonite addition dose of 5 Kg/T, however at a dose of 7.5 Kg/T there was a decrease, this occurred due to flocculation.

3.4.Carrageenan + Bentonite

The next result is the addition of Carrageenan + Bentonite as a wet strength agent, where the results can be seen in **Table 3.4.1.**

Dose (Kg/T)	Dry Tensile (Nm/g)	Wet Tensile (Nm/g)	Tearing (mNm2/g)	Bursting (kPam2/g)	Bulky (cm3/g)
0	73,04	20,67	0,44	3,57	1,78
2,5	82,24	23,82	0,73	4,28	1,87
5	84,42	24,05	0,75	4,35	1,89
7,5	84,17	23,08	0,68	4	1,87
10	82,34	22,16	0,65	3,76	1,83

Table 3.4.1. Results of Adding Carrageenan + Bentonite as Wet Strength Agent.

At a dose of 5 Kg/T, the highest value of Bentonite as a wet strength agent was obtained but at a dose of 7.5 Kg/T to a dose of 10 Kg/T there was a decrease, this was due to flocculation. Too much agent added will result in polymer flocculation, this is due to disruption of fiber distribution and decreases the strength of the paper.

4. CONCLUSION

The results of the analysis carried out showed that several materials could be used as Alternative chemicals that can be used as wet strength agents for making paper that is resistant in wet conditions. These alternative materials come from plants and marine animals which are of course environmentally friendly. With the many alternative materials used in making waterproof paper, it makes us creative and innovative in using the materials around us. So that paper needs in the world, especially in Indonesia, can be achieved, with many alternative materials that can be used.

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