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Dissolving Sulpite Pulp From Rubberwood

As one of countermeasures for securing raw material wood for pulp we aimed at the utilization of rubber wood and studied its aptitude as dissolving sulfite pulp.

The fibre dimension of rubber wood (Hevea Brasiliensis) remains within the fluctuation range of diversified hardwood of Japanese origin and its characteristics in the chemical composition are few pentosan content and rather much ash content. We have secured the most suitable sulfite pulping method and confirmed that the quality of dissolving sulfite pulp, viscose reaction and filament quality were satisfactory.

Based on the above result, we have been engaging in the production of dissolving pulp by using the mixture of hardwood of Japanese origin and rubber wood since 1967.

I. INTRODUCTION

The switching of raw material from Soft wood to hardwood has started since about 1955 in the Japanese pulp industry due to its economical requirements. At present, 65 per cent of material wood for pulp are obtained from hardwood, especially the ratio of hardwood in the dissolving pulp wood is well over 90 per cent. Moreover, the Japanese hardwood have a variety of more than 40 kinds and the ratio of a single kind of wood is accordingly very low. In other words, all the kinds of Japanese hardwood are presently being used as the raw material for pulp in Japan.

On the other hand, the development and procurement of hardwood in Japan are not in a position to catch up with the demand for pulp wood which is rapidly increasing year after year, and the Japanese paper and pulp industries are suffering from the price hike of pulp material wood as well as from the difficulty in securing the required amount of wood and they are intensively seeking for the measure to secure the economical and stabilized supply of pulp material.

Rubber wood is planted in large quantity in southeast Asia, and as it is replanted after 30-40 years of age, a great amount of waste wood is left at that time. These waste woods have begun to attract the attention of T. D. peel and other many researchers as a pulp material. They report on discoloration of rubber wood, characteristics of rubber wood (1), (2), (3), (8), (11), economy of it, pulp aptitude (4), (6), (8), (11), aptitude for paper making (7) and fibre board (4) (6). However, the report on dissolving pulp is restricted to only those on prehydrolysis dissolving kraft pulp.

We, for our part, have conducted a series of studies on chemical ground pulp, semi-chemical pulp, kraft pulp sulfite pulp etc. and ascertained that rubber wood is usable for making pulp just same as the case of Japanese hardwood and since 1966 we have been using it in the production of BKP, BSP etc. on the commercial base.

Now that the deterioration of the quality of the so-called purchased chips is being on the way, the rubber wood has a strong point of being purchased on a stabilized price abundantly as a single kind of wood. Conquering the change of quality due to storage as well as the latex trouble technically, rubber wood has been used for the production of dissolving pulp mixed with Japanese hardwood since 1967.

This report is on the DSP aptitude of rubber wood.

II. SPECIAL CHARACTERISTICS OF RUBBER WOOD.

As a result of a preliminary test, it has been proved that the tapping portion has plenty of bark latex included in the ligneous part and the result of cooking is also bad, resulting in the deterioration of pulp quality. Therefore, we regarded it as unfit for the purpose. Now, we explain the special characteristics of rubber wood mainly as a normal wood.

1) Specific gravity (Table I)

The specific gravity of rubber wood on absolute dry base amounts to 0.54, a little lower than the average Japanese hardwood, and its difference is also small. Thus, the specific gravity of rubber wood can be regarded as similar to that of Japanese hardwood.

2) Structural elements of wood (Table II).

Rubber wood has fewer vessels and more wood fiber and parenchyma compared with Japanese hardwood.

In the vessel is found tylose or rubbery material and in the parenchyma is detected crystals or starch.

This rubbery material is the latex permeated from the latex tube of cambium into the vessels around the circumference of the cut surface in case the rubber wood is cut down into the given length, and it is one of the biggest obstacle in using rubber wood as material for pulp. This is also one of the most difficult matters re-

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Table I. Specific Gravity of Rubber Wood

	Rubber wood (n = 45)	Japanese major hardwood (n =35)
Minimum	0.54	0.56
Maximum	0.64	0.73
Average	0.44	0.40

quiring the most skilled treatment in the barking process as well as in the pulping process.

Starch is regarded as a major cause of microorganism trouble during the timber storing.

3) Fiber dimension (Table III)

Wood fiber of rubber wood is longer and wider than that of Japanese hardwood, but is thin in its membrane thickness.

However, the vessel element is a little longer and wider the membrane thickness is also a little larger. Therefor, considering the fluctuation of supply of Japanese hardwood of various kinds and types, there is no weak point in rubber wood as dissolving pulp.

4) Chemical Composition (Table IV)

Though the fluctuation range of chemical composition is rather large as a single type of trees, it is similar to that of Japanese hardwood on an average. The character of rubber wood is small content of pentosan and rather much contents of ash, hot water soluble matter.

Such an extent of ash has no bad effect when we think of ash being eliminated in the pulping process.

5) Change due to storage time (Table V)

Considering the saseness of barking, the prevention of latex fixing, etc., it is desirable to bark rubber wood at a proper time after cutting down. We conducted yard storage test for 10 months and water storage test for 6 months on the completely barked timber and investigaged the change due to time elapsed.

Table II. Stractural elements of wood and their composition

	Wood fiber	Vessel	Parenchyma
Rubber wood (n = 17)	61.5%	9.5%	29.0%
Japanese major hardwood	58.0	19.0	23.0

Table III. Fiber dimention

Wood species		Length (n % 16)	Width average	Membrane thickness average
Wood fiber	Rubber wood	2.02—1.49—0.66	21.8	3.0
	Japanese major hardwood	1.93—1.20—0.35	18.8	3.4
Vessel	Rubber wood	1.23—0.74—0.36	17.6	4.0
	Japanese major hardwood	1.20—0.48—0.12	73.0	2.2

Table IV. Chemical composition

		Rubber wood (n = 16)	Japanese major hardwood (n =25)
Holocellulose	%	87.6—82.1—79.8	84.2
Lignin	%	23.1—20.2—17.6	20.7
Alcohol-benzene extracts	%	3.0— 2.1— 1.0	2.1
Pentosan	%	18.2—16.3—15.1	19.0
Ash	%	1.2— 0.9— 0.6	0.4
Hot water soluble matter	%	7.7— 5.9— 3.5	5.1
1%NaOH soly	%	21.8—18.8—17.2	18.5

Table V. Change due to storage time

Seasoning	Yard 1 month	Yard 6 months	Yard 10 months	Water 6 months
Specific gravity	0.57	0.53	0.49	0.45
Generation of blue staining fungus %	0	50	30	0
Holocellulose	87.6	82.2	81.2	81.9

a) Blue staining fungus has grown enormously due to yard storage. Holocellulose decreased and specific gravity was also reduced to a large extent.

b) Storage in water prevents blue staining fungus from growing, but causes large reduction in specific gravity.

c) The generation of blue staining fungus is regarded attributable to hot water soluble matter, especially to starch content. It is expected to some extent that OCS of rubber wood chips or use of anti-mildew chemicals during ocean transportation will have an effect to prevent the quality change of wood chips.

III. PULPING AND CHARACTERISTIC OF PULP.

1) Test method

a) Tested timber

Chips made from completely barked timber, the same chips which has blue staining fungus naturally generated after storage

for 21 days, as well as the mixture of the above two, have been used for cooking test. Those chips with blue staining fungus indicated 7.4% of weight decrease.
The **table VI** shows the chemical composition.

Also, in order to investigate the fluctuation due to the difference of growing conditions of individual rubber wood, etc., six pieces of test timber with specific gravity of 0.44—0.57 have been adopted.

b) Cooking

By using 20 autoclave a sulfite pulp steam cooking has been carried out in the following order:

Chip	3300g
Composition of cooking liq.	Total SO_2 8.0% Combine SO_2 1.12%
cooking liq./chip	4 lts/kg.
Max. temperature	143°C Max. pressure 8 kg/cm^2
Cooking time	Normal temperature . . . . . . 1 hr. 100°C . . . . 4.5 hrs. 143°C

The effect of cooking has been studied by changing the keeping time.

c) Refining and bleaching

The effect of the result of 6 stage bleaching (C-E-E-H-D) has been studied.

d) Viscose

Test material	400g (O.D.)
Concentration of NaOH	17.5%
Consistecy of slurry	4%
Temperature	50°C
Duration	30 min.
Revolution	600 r.p.m.
P. W. R.	2.95 (O. D.)
Shredding	20°C. 1 hr.
Xanthation	CS_2 35%, 26°C, 3 hrs.
Disolution	Cellulose content 3% Total alkali 6% 20 C 3 hrs.

e) Spinning test.

Nozzle 0.06mm	1.00 holes
Composition of spinning bath:	H_2SO_4 8.35 0.05 W% $ZnSO_4$ 1.30 0.05 W% Na^2SO_4 25.5 0.05 W% Temperature 28°C
Secondary bath:	Hot water 92°C
Secondary stretch:	1.30
Filament quality test:	Rayon and staple test method (118 1015)

Table VI Chemica composition of chips as test materials for cooking.

		Normal chips	Blue staining chips
Specific gravity	%	0.54	0.50
Pentosan content	%	13.83	15.41
Alcohol-benzene extracts	%	1.91	1.53
Ash content	%	0.74	0.83
Lighin	%	19.62	21.96
Hot water soluble matter	%	6.54	4.71
Holocellulose	%	82.30	82.21

11) Results and Discussion

a) Cooking

Rubber wood is apt to generate blue staining fungus during storage period. Therefore, it is necessary to study sulfite pulping of rubber wood in the case of normal chips as well as blue staining fungus chips. The **table VII** shows the result of this study. In case the relative viscosity of unbleached pulp is same, blue staining fungus chips are apt to have a higher pulp yield than the case of normal chips. However, as the specific gravity decreases, the unbleached pulp yield per one cubic meter is apt to have a lower value than normal chips. The unbleached pulp with blue staining fungus is very rich in $KMnO_4$ value and demands increasingly the chemicals of C and NaOH. When the cooking is further processed to reduced $KMnO_4$ value, the consumption of chemicals decreases and the pulp yield is reduced.

However, as shown in the **Table VIII**, it will be impossible to oxidize and bleach sufficiently to maintain the standard viscosity of refined pulp in case the relative viscosity of unbleached pulp is 6, and the whiteness of the unbleached pulp is lowed down to 86 per cent even it is bleached with ClO_2.

On the other hand, if the relative viscosity of unbleached pulp exceeds 8, the screening residue is increased at a rapid speed even in the case of normal chips, and pulp yield will decrease.

Table VII. Cooking of blue staining fungus chips.

Chips	Specific gravity	Relative Viscosity of unbleached pulp	Pulp Yield %	Screenings	$KMnO_4$ value	Pulp yield per $1m^3$ Kg	Pulp yield per $1m^3$ Index
		10	40.6	5.6	10.2	219	100
Normal	0.54	8	41.9	2.8	7.5	226	100
		6	41.9	0.3	5.4	226	100
Normal 50%		10	41.7	5.3	11.5	217	99
Blue staining	0.52	8	42.9	2.6	9.5	223	99
fungus 50%		6	42.5	0.6	8.0	221	98
Blue		10	43.1	4.0	12.5	215	98
staining	0.50	8	43.9	1.0	10.8	220	96
fungus		6	43.7	0.5	9.3	219	97

Note 1. The figures in the above table have been obtained from the Inter polation based on the many times of cooking.

2. The index for pulp yield per $1m^3$ have been obtained by setting the index of normal pulp at 100.

3. Viscosity JIS 0.5% CAM 10 8 6
TAPPI 1% CAM cp 80 53 32

Therefore, judging from the pulp yield, the consumption of chemicals and the quality of pulp refined and bleached, the most suitable relative viscosity of the unbleached pulp of rubber wood shall be the value balanced with bleaching, namely, from 8 to 8.5.

Further, according to Table VIII, it is clear that the pulp made from blue staining fungus chips are apt to be rich in alcohol-benzene extracts.

As stated above, the economy of sulfite pulping from rubber wood depends largely upon the growth of blue staining fungus.

b) Effect of cooking and refining on reactivity

As a general measure to value the reactivity the clogging constant "kw" has been adopted in **Table VIII.**

By reducing the relative viscosity of unbleached pulp, in other words, by proceeding cooking, the reactivity tends to rise, while kw value increases in the case of low viscosity cooking if blue staining fungus increases extremely. This is perhaps due to insufficient oxidizing bleaching for maintaining the standard relative viscosity as seen in the case of whiteness.

As for the effect of refining, it can be noted that the reactivity is greatly raised if refined upto the extent of alpha cellulose 92 per cent, while there is no remarkable difference in the kw value when the relative viscosity of unbleached pulp is high and the pulp is refined to the extent of alpha cellulose 88-90 per cent.
In case the relative viscosity of unbleached pulp is lowered extremely to 6, the effect of refining is not seen so much.

Judging from the above, it is presumed that the effect on the reaction is much caused by cooking extent than refining extent. Therefore, in order to elevate the reaction of pulp of rubber wood the most suitable relative viscosity of unbleached pulp shall be 8-8.5 (TAPPI 1% CAM 53-60 CP) where cooking is balanced with refining and bleaching and where unbleached pulp yield shows the highest value as mentioned above. It is also interesting to note that blue staining fungus ships do not always show any bad reaction except the case where cooking is extremely proceeded, and that kw value obtained in this test also shows rather small value. This is perhaps due to the fact that the required quantity of the refined chemicals is large and the chips have been attacked heavily. Further, when blue staining fungus increases, the alkali-benzene extracts increase accordingly. The cause is still to be solved whether it is due to the increase of chlorination of unsaturated fatty acids ester.

c) Comparison between dissolving sulfite pulp of rubber wood and that of Japanese hardwood.

Table IX shows the comparison of fluctuation of reaction between Japanese hardwood and six kinds of rubber wood having different specific gravity in consideration of the difference due to growth conditions or seed of individual rubber wood.

Table VIII Relation between relative viscosity of unbleached pulp. refining and viscose reaction.

Test chips		Normal chips			Normal chips 50% Blue staining fungus chips 50%			Blue staining fungus chips			Normal chip				Normal chips 50% Blue staining fungus chips 50%			Blue staining fungus chips		
Viscosity of unbleached-pulp			10			10			10		7.4		6			6			6	
Alpha cellulose content	%	87.7	89.3	92.1	87.7	89.2	91.4	88.8	89.7	92.1	90.4	89.5	90.7	92.3	89.0	90.0	92.2	88.3	90.0	91.9
Beta cellulose content	%	4.8	4.7	3.6	4.1	4.6	3.7	4.2	3.8	3.6	4.3	5.6	5.3	4.7	4.8	5.0	4.5	5.4	5.1	4.7
Relative viscosity		4.6	4.6	4.5	5.0	4.7	4.7	5.1	4.7	4.8	4.9	4.6	4.5	4.4	5.2	4.8	4.8	5.0	5.0	5.0
Pentosan content	%	4.7	3.8	3.9	5.9	4.6	4.0	5.8	4.6	3.9	3.6	3.9	2.8	2.4	4.2	3.4	2.8	4.5	3.4	2.6
Alcohol-benzene extracts	%	0.16	0.12	0.08	0.26	0.25	0.18	0.33	0.32	0.29	0.11	0.13	0.10	0.07	0.23	0.21	0.18	0.33	0.29	0.26
Copper number		1.0	1.0	0.7	1.2	1.1	0.9	1.2	1.1	0.8	1.2	1.5	1.5	1.0	1.6	1.5	1.2	1.8	1.6	1.2
Ash content	%	0.10	0.08	0.07	0.09	0.07	0.05	0.03	0.06	0.05	0.04	0.03	0.03	0.04	0.03	0.03	0.02	0.04	0.05	0.03
Whiteness	%	95	95	94	94	94	93	92	92	93	95	94	95	96	91	93	91	90	85	86
KW		315	328	221	324	274	210	208	203	154	216	193	199	231	199	191	161	290	249	226

Note 1. Method of analysis : JIS p8101

2. Viscosity : JIS 0.5% CAM 10 7.4 6

TAPPI 1% CAM cp 80 45 32

Table IX Viscose reactivity and spinning suitability of rubber wood

		Rubber Wood						Misture of Japanese hardwood	
Pulp	Specific gravity	0.44	0.48	0.50	0.53	0.56	0.57	0.53 '	0.56
	Blue staining fungus								
	Alpha cellulose %	89.4	87.1	88.7	89.5	88.4	89.3	88.4	89.5
	Beta Cellulose %	4.8	5.1	4.3	3.9	4.4	3.7	4.1	5.2
	Relative viscosity	4.7	4.6	4.9	4.8	4.6	4.8	4.6	4.9
	Pentosan content %	4.4	5.5	4.9	4.7	5.5	4.7	5.5	6.3
Viscose	Drainage cc/sec.	8.6	9.7	8.4	12.0	2.99	3.14	3.06	3.19
	Pressability	3.10	3.14	3.06	3.11	44.7	42.1	41.5	45.1
	value	43.5	42.4	41.5	42.6z	276	160	180	270
	kw	272	212	245	240				
Spinning quality	Denier	—	1.70	1.72	1.70	1.69	—	1.68	1.69
	Dry strength g/d	—	3.08	3.09	2.90	3.07	—	2.95	3.01
	Wet strength ,,	—	1.88	1.84	1.78	1.96	—	1.84	1.94
	Knot strength	—	1.76	1.82	1.73	1.66	—	1.66	1.75
	Loop strength	—	1.89	1.92	1.97	1.88	—	1.89	2.03
	Dry elongation	—	18.4	17.5	17.8	16.8	—	17.1	17.6
	Wet elongation	—	21.0	19.9	21.0	19.3	—	20.9	21.6

Note: Pressability means the press weight ratio of alkali cellulose under a certain pressure.

As the growing conditions of blue staining fungus were different owing to the difference in the storage condition of raw material wood, it can also be regarded as a general variation of raw material rubber wood. Cooking has been carried out on the most suitable conditions mentioned above. Although some rubber wood show a remarkable reactivity such as 160kw, they are about same with the value of Japanese hardwood mixed chips in general.

Rubber wood are also same with Japanese hardwood mixed chips in their drainage and pressability of alkali-cellulose. However, contrary to the former case, the chips with higher growth ratio of blue staining fungus do not always show smaller valve of kw. This shows that the difference between individual rubber trees is large. Also, any correlation between specific gravity, kw and filament quality can not be found. In filament quality too, rubber wood show about same value as that of Japanese hardwood mixed chips.

As a result of the foregoing consideration, we recognized that the dissolving sulfite pulp of rubber wood indicates the same behaviors as that of Japanese hardwood mixed chips, and we also came to confirm in the collaboration with rayon making factory that the dissolving sulfite pulp made from rubber wood is not inferior to that made from Japanese hardwood mixed chips and is usable as raw material.

Table X shows the result obtained from rayon filament test of dissolving sulfite pulp of scftwood (Japanese and imported) and of rubber wood. According to this table, rubber wood has a good reactivity as well as good spinning aptitude, and the conclusion is that it is possible to obtain rayon filament almost same in filament quality.

d) Effect of latex on viscose

We have been striving for preventing latex from attaching to or penetrating into the ligneous surfaces and the cut sections in preparing barked rubbed wood. However, there still remains 0.01-0.02 per cent of latex in pulp.

In case when rubber wood is to be prepared in large volume on the commercial base, it is afraid that attachment of latex will further increase. Therefore, we studied the effect of latx on the reactivity and filament quality of viscose by adding 0.02 per cent

Table X Rayon filament test at rayon factory

			DSP from Rubber wood	DSP from softwood (Japanese)	DSP from softwood (imported)
Pulp	Alpha cellulose %		92.5	92.4	93.0
	Beta cellulose %		3.7	3.7	4.9
	Pentosan content %		2.3	2.2	1.4
Viscose	Undis- solved	Large	29	48	50
		Small	708	1054	1000
	kw		189	168	154
Spinning	Fuzz		none	none	none
	Clogging		none	none	none
	Spinnability		good	good	good
Spinning quality	Denier		118	116	116
	Dry strength	g/d	1.79	1.74	1.75
	Wet strength	,,	0.80	0.78	0.75
	Dry elongation	,,	19.2	20.3	20.0
	Wet elongation	,,	28.6	31.2	27.5
	Secondary swelling		91.1	93.7	95.8
	Degree of polymerization		254	252	276
	Copper number		0.34	0.37	0.36
	M.B. value		2.08	1.99	2.07
	Appearance		Normal	Normal	Normal

and 0.2 per cent latex to the pulp made from Japanese hardwood as a model testing.

Table XI shows that no serious effect will be caused over kw value and filament quality even if latex content amounts to 2 per cent namely, 10 times larger than the maximum latex content of rubber wood dissolving sulfite pulp.

From the above table, it can be recognized that neither viscose trouble nor spinning trouble will be caused by latex if the barking work of rubber wood is attentively controlled. It is more safer if rubber wood is used mixed with Japanese hardwood on the commercial basis.

However, the elimination of latex should be carried out more intensively throughout the pulping process from wood preparation so as to prevent troubles by latex to be accumulated in the course of pulping process in case rubber wood is incessantly used as raw material for pulp.

IV. Conclusion

1. The specific gravity of rubber tree is 0.54, almost same as Japanese hardwood. It is rich in parenchyma while vessel elements are not so many. Though its wod fiber is rather long and wide, the membrane thickness is thin. The vessel elements are a little long and wide in size and its membrane is large. However, these dimensions are not so deviated as to affect the qua-

Table XI Effect of latex on viscose and filament quality

Pulp	Alpha cellulose %		89.5	
	Beta cellulose %		4.9	
	Relative viscosity		4.7	
	Pentosan content %		6.0	
	Latex adding	0	0.02	0.2
Viscose	Viscose kw	264	242	260
	Denier	1.66	1.68	1.68
	Dry strength g/d	2.85	2.84	2.89
	Wet strength „	1.73	1.73	1.75
	Knot strength „	1.78	1.80	1.68
Filament quality	Loop strength „	1.99	2.03	1.92
	Dry elongation „	18.0	18.2	17.7
	Wet elongation „	21.5	21.8	21.2

Note : Preparation of adding latex.

Sulfite cooking wind dried latex film and bleach it in five stages (C-E-E-H-D). Then, make it into fine grain and immerse into 17.5% NaOH solution. Thus adding latex is obtained. This adding latex has been added at the time of shredding alkali cellulose.

lity of dissolving pulp, judging from the fluctuation of dimensions in the case of Japanese hardwood.

Starch is detected in parenchyma cells.

Attachment to or penetration into the surfaces of sections of wood part can also be observed.

2. Rubber wood is rich in ash content and hot water soluble matter but not in pentosan content as compared with Japanese hardwood.

3. In case of rubber wood. blue staining fungus will grow due to storage of wood, the specific gravity will decrease and the consumption of chemicals in the refining and bleaching will increase.

4. Considering the economical aspects, pulp quality and viscose reactivity, the most suitable unbleached pulp viscosity in the production of dissolving sulfite pulp from rubber tree will be 8.0-8.5.

5. The viscose reactivity and filament quality of rubber wood dissolving sulfite pulp are almost same as those of Japanese hardwood.

6. The latex context of pulp is less than 0.02% and has no influence upon the viscose and filament quality.

If mixed with Japanese hardwood, the safety in using rubber wood becomes more assured. Thus, we are manufacturing dissolving sulfite pulp from rubber wood by mixing it with Japanese hardwood.

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