Studies on the Preparation of Chemimechanical Pulp from Keora (S. apetala)

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The world is facing a serious shortage of cellulosic raw materials for paper making. The gap between the demand and supply of wood is expected to widen in the closing years of the century. The utilization of the hardwood resources of the world for pulp manufacture has assumed vital importance. The hardwoods are the predominant species of tropical and sub-tropical natural forests and plantattrons. There are some inherent problems of utiliziing hardwoods for the conventional pulping processes. Only the kraft and NSSC Processes can be used for all types of hardwoods. Unbleached hardwood sulphate pulps are of limited interest because their strength properties are not comparable with those of pine kraft pulps. Though bleached sulphate pulp is an excellent raw material for writing and printing papers, but a certain percentage of long fiber pulps is considered to be essential in the furnish for the wet web strength on the paper machine and tear strength in the final sheet. However, it should be kept in mind that fine papers are being produced today using 100 percent hardwoods. The main disadvantage of the kraft process for hardwood pulping is the very high investment costs and the kraft mill has to be built fairly large to be economically viable. Because of the low consumption of chemicals in NSSC process, recovery is not essential and such mills can be built in small sizes NSSC hardwood pulps are used for the corrugating medium. Since it is almost impossible to bleach NSSC pulps to an acceptable brightness, these pulps are therefore not used for writing and printing papers. Hardwoods also do not respond well to the mechanical pulping processes because of the morphological reasons. The pulps obtained have a significant lower strength than corresponding conventional pulps from spruce.

It means that conventional pulping processes are not suitable for producing bleached or light coloured hardwood pulps in a mill of reasonable capacity. In the recent past, high yield pulping processes offered the possibilities of finding soultions to this problem. Chemimechanical pulping is the process which can be used for the pulping of hardwoods and such pulps can be mixed in the furnish for the production of newsprint, writing and printing grade papers. Chemimechanical process can utilize most of the hardwood species satisfactorily and a wide variety of pulps from groundwood to semichemical pulp can be produced. The yield is high and the chemical consumption is low and there is no need of the recovery of spent liquor. The process is simple with low capital investment and reduced production cost.

The purpose of the present study was to find out the possibilities of producing chemimechanical pulps from KEORA, a hardwood from Bangladesh, with acceptable strength, opacity and brightness using cold soda process. The aim is to mix the cold soda chemimechanical pulp in the furnish to produce newsprint and writing papers of higher commercial value.

EXPERIMENTAL—

Raw Material :

The raw material used for this study was KEORA (S. apetala) from Bangladesh. The density of the wood is 490 kg/m^3. The microphotographs of the wood sections revealed that it contained thin walled fibres. The wood was chipped into small sizes of 10–12 mm in a laboratory chipper.

Chemical Pretreatment :

A fair amount of knowledge exists today regarding the chemical pretreatment of chips before refining. The chemical pretreatment can be performed with alkali, bisulfite, neutral sulfite or

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alkaline sulfite. Hardwoods respond in a different way than softwoods to such treatments. In the present study, the chemical pretreatment is being carried out with NaOH using small amount of Na_2SO_3. The chemical preteatment and cooking conditions are give below.

Table—1

CHEMICAL PRETREATMENT AND COOKING CONDITIONS :

Chemicals charged on O.D. wood, %	[NaOH	= 5.0
	[Na_2SO_3	= 1.0
	Cooking Temperature°C	= 70
	Cooking time, min.	= 60
	Cooking yield,%	= 92

The cooking was performed in a 50 litre rotary digester filled with 5.5 kg. O.D. chips which were first steamed at 1.0 atmospheric pressure for 15 minutes. The cooking liquor was then pumped into the digester. The chips were impregnated with nitrogen gas for 3 minutes at a pressure of 8 KP/cm² which was maintained during the cook. The cooking was then carried out at 70°C for about 1 hr. to get a yield of about 92%. The excess liquor was drained out after the cooking, and the chips were collected.

REFINING :

The chips were hot alkali refined in a 12" sprout waldron disc. refiner equipped with C-2976 discs The refining was carried out in the consistency range of 9-10% in different stages to get the pulp of desired freeness. The hot water was fed by a feed pump to maintain the refining temperature. Table - 2 below gives the refining conditions.

Table—2

REFINING CONDITIONS IN SPROUT WALDRON.

Refining stage	Chips feed rate O.D. g/min	Consistency %	Freeness CSF,ml
1.	200	10.0	300
2.	200	9.8	160
3.	200	9.6	130
4.	200	9.5	60

Pulp Evaluation :

The refined pulp from different stages of refining was properly washed in a laboratory centrifuge. The drainage properties of the pulps were determined by CSF tester. The fiber fractionation was carried out in a Bauer McNett classifier. Laboratory hand sheets were prepared in accordance with SCAN standards. The sheets were tested for strength and optical properties as per SCAN standards The hand sheet properties are given in Table - 3.

TABLE--3 HAND SHEET PROPERTIES

Refining Stage		1	2	3	4
Freeness, CSF, ml		300	160	130	60
Bauer Mc-Nett Classification, %	+28	14.5	11.0	9.0	4.9
	28/48	35 3	31.6	31.4	31.3
	48/100	29.3	28.1	28.0	27.7
	100/200	8.6	8.7	9.5	10.7
	—200	12 3	20.6	22.1	25.7
Density, Kg/m³		360	393	407	464
Tensile Index KNm/Kg		22.5	27.2	32.7	43.5
Tear Index Nm²/Kg		2.8	3.1	3 5	3.6
Brightness ISO		53 4	53.4	53.2	53.0
Scattering coefficient m²/Kg		41.4	43 5	44.1	48.0

Bleaching :

The aim was to bleach the pulps to two clearly defined brightness levels, one around 60° ISO for newsprint furnish and the other to 75-80° ISO for writing, printing grades. The pulp of 300 CSF was washed properly and then used for bleaching experiments.

In the lower brightness range, sodium hypochlorite was used in a single stage. The bleaching was carried out in plastic bags in a constant temperature bath. The bleaching trials were performed with different charges of % active chlorine on O D. pulp. The bleaching conditions are given in Table—4.

The bleaching was also performed using hydrogen peroxide in one stage. The bleaching was carried out in plastie bags. Clarene S was used as peroxide stabilizer and NaOH was used to maintain the pH during bleaching. The bleaching conditions are given in Table—5.

TABLE—4 SINGLE STAGE HYPOCHLORITE BLEACHING

Unbleached ISO Brightness, = 53.4
Bleaching Time, min. = 60
Bleaching Temperature, °C = 40
Consistency, % = 6.0

Amount of % aCl chargen as Na Hypochlorite	2	3	4	5	6	7	8	9	11	12	14
Residual%aCl	0.02	0.025	0.03	0.04	0.07	0.08	0.19	0.21	0.28	0.39	0.77
Final pH	9.5	9.4	9.3	9.0	9.1	9.2	9.4	9.2	9.3	9.3	9.4
Final ISO Brightness	55.3	56.6	57.9	59.6	61.9	63.0	63.1	63.7	64.6	64.8	65.6

TABLE—5 PEROXIDE BLEACHING OF COLD SODA CHEMIMECHANICAL PULP FROM KEORA

Initial Brighsness = 53.4°
Temperature = 70°C
Consistency = 10%

O_2 Charged % O.D Pulp	0.5			1.0			2.0			4.0
NaOH % O.D. Pulp	0.8			0.8			0.8			0.8
Clarene % O.D. pulp	1.0			1.0			1.0			1.0
Time, HR	1	2	4	1	2	4	1	2	4	2
Residual H_2O_2 %O.D. Pulp	0.20	0.13	0.09	0.43	0.38	0.30	1.03	0.85	0.71	2.50
Brightness O Elrepho	62.9	63.7	65.0	64.9	66.6	68.3	67.1	70.4	71.1	71.4

One stage peroxide bleaching resulted in a final ISO brightness of 70°. The pulp was bleached to higher brightness values by P/HS (Peroxide/ Hydrosulfite) bleaching sequence. The pulp from first peroxide stage was washed free of alkali. The pulp was then bleached with sodium hydrosulphite in the second stage. Sodium hydrosulphite bleaching sequence. The pulp was then bleached with sodium hydrosulfite in the second stage. Sodium hydrosulfite bleaching was carried out in plastic bottles, and care was taken to see that the presence of air inside the bottle, was avoided. The bleaching conditions for two stage P/HS sequence are givan in Table—6.

TABLE—6 TWO STAGE PEROXIDE HYDROSULFITE (PH) BLEACHING

INITIAL BRIGHTNESS = 53.4°

I STAGE (PEROXIDE)

% H_2O_2 Charged on O.D. Pulp	=	2.0
% NaOH on O.D. Pulp	=	0.8
% Clarene-S on O.D. Pulp	=	1.0
Time, HR	=	2
Temp. °C	=	70
Consistency, %	=	10
% Residual H_2O_2 on O.D. Pulp	=	0.84
Final pH	=	9.4
Brightness	=	70.2

II STAGE (HYDROSULFITE)

Time = 2 HR Temp. = 70°C Consistency = 4.5 %

% Sodium Hydrosulfite on O.D. Pulp	0.5	1.0	1.2	1.6
% Sodium Tripolyphosphate on O.D. Pulp	0.4	0.4	0.4	0.4
Final pH	6.8	6.7	6.7	6.2
Final Brightness	72.8	76.1	77.5	78.8

Preparation of pulp for paper machine runs :

The cooking was carried out in 50 litre digester to get the enough pulp for running on the paper machine. The cooked chips were refined in a 12" Sprout Waldron laboratory refiner with discs C-2976. The refined pulp after first stage of refining was washed free of alkali, and then mixed properly. This pulp was used for bleaching with Sodium hypochlorite. The bleaching was carried out in the same Sprout Waldran used as a mixer. The refiner worked at very open gap. The hypochlorite was mixed with the hot water and then pumped in to the disc refiner. The conditions were so adjusted that the time of mixing in Sprout Waldron was the minimum for the prevailing conditions. The bleaching and refiner conditions are given below.

Pulp feeding rate, g O.D. pulp	= 475
%oCl charged as hypochlorite on O.D.Pulp	= 6.0
Consistency, %	= 6.0
Temperature, °C	= 40
Mixing time, min	= 18

The hypochlorite bleached pulp was stored in the buckets and the amount of residual chlorine was found out after every 15 min. A total bleaching time of 1 hr. was enough to consume most of the aCl charged. Sodium bisulfite was mixed to neutralise the alkali in the bleached pulp and a pH of 4-5 was maintained. The bleached pulp was then refined in the second stage to achieve the proper freeness value. The handsheets were prepared from the hypobleached pulp and then tested as per SCAN standards. The results are given in Table—7.

The pulp from the first refining stage was washed free of alkali, and then mixed properly. This pulp was refined in the second stage in Sprout Waldron to get the required freeness. The refined pulp was then bleached with hydrogen peroxide. The mixing was carried out in the Sprout Waldron refiner. H_2O_2 was mixed with hot water and pumped in to the refiner. The following conditions were maintained.

Pulp feeding rate, g O.D./min,	= 445
% H_2O_2 charged on O.D. pulp	= 2.0
% NaOH charged on O.D. pulp	= 1.0
% Clarene S charged on O.D. pulp	= 1.0
Temperature during bleaching, °C	= 80
Initial pH of bleaching liquor	= 11.2
Bleaching time, hr	= 2
Residual H_2O_2, %	= 0.90
Final pH of residual liquor	= 9.5

The pulp was then put into the plastic buckets and properly covered. A total bleaching time of 2 hr was enough which was decided by following up the amount of residual H_2O_2 after every 15 min.

The peroxide bleached pulp was washed in a centrifuge to remove as much alkali as possible. Sodium bisulfite was then added to the peroxide bleached pulp to bring down the pH to around 6.0.

The pulp was then distributed into different buckets of 45 litre capacity. The same amount of sodium hydrosulfite was added to the buckets and hot water was used to maintain a temperature of 70°C and a consistency of 4-4.5%. The amounts were so calculated that after putting everything in to the buckets, the buckets were completely filled up. This was done to ensure minimum amount of oxygen to be in contact with the pulp. The bleaching time of 1 hr is sufficient. The bleaching conditions are given below.

Sodium hydrosulfite charged, %	= 1.5
Tripolyphosphate charged, %	= 0.4
Final pH	= 6.0
Temperature, °C	= 70

The handsheets were prepared from P/HS bleached pulp and then tested. The results are given in Table–7.

TABLE–7 PHYSICAL AND OPTICAL PROPERTIES OF HAND SHEETS PREPARED FROM DIFFERENT PULPS USED IN THE FURNISH FOR PAPER MACHINE RUNS

The different pulps used are abbreviated as follows :

1. Chemimechanical Keora Pulp (Hypo Bleached) CMP (H)
2. Chemimechanical Keora Pulp (P/HS Bleached) CMP (P/HS)
3. Thermomechanical pulp from pine TMP
4. Semi Bleached Pine Kraft SBK
5. Bleached Kraft Pine (Tofte 90) BK
6. Eucalyptus Hardwood Kraft from Borregaard EK

Type of Pulp	CMP.H)	CMP(P/HS)	EK	SBK	BK	TMP
Freeness CSF	45	100	—	—	—	—
°SR	—	—	26	32	23	72
Basis Weight g/m²	68.0	64.6	67.0	65.0	63.0	54.5
Density Kg/m³	478	434	604	658	620	385
Tensile index KNm/kg	44.6	37.4	35.8	74.4	64 3	26.7
Tear Index Nm²/kg	3.3	3.5	5.7	10.9	14.6	6.40
Brightness ISO	56.0	71.0	81.1	61.6	80.5	56.9
Y-Value	73.1	84.0	87.0	75.5	84.6	65.6
Opacity, %	94.5	86.8	83.1	80.6	75.3	96.4
Scatt. Coeff. m²/kg	50.4	44.9	42.2	27.7	29.5	58 7

The hypochlorite bleached chemimechanical pulp of 56° brightness was used in combination with semibleached kraft to produce newsprint. This was also mixed with TMP for producing newsprint.

The peroxide/hydrosulfite bleached pulp of 71° ISO brightness was mixed in different proportions with bleached pine kraft and eucalyptus to produce writing paper.

DISCUSSION :

It is clear from Table–3 that the pulp obtained from KEORA around 92% yield is of acceptable quality (Tensile Index = 43.5 KNm/Kg and scattering coefficient = 48.0 m^2/Kg).

Chemimechanical pulp (unbleached brightness 53.4°) was bleached to two different ranges of brightness, hypochlorite bleaching conditions and results are given in Table—4. Fig. gives the variation of brightness with % aCl charged. It is interesting to note that the pulp could be bleached to satisfactory brightness with low amount of % aCl (6—7 %) charged as Sodium hypochlorite. Peroxide bleaching (one stage) was carried out for the higher brightness values. The bleaching conditions and results are given in Table—5. It is found that 2% H_2O_2 charged on C.D. pulp is the most suitable at a temperature of 70°C with a bleaching time of 2 hrs for a ISO brightness gain of 17°. Fig. 2 shows the results of peroxide bleaching.

Two stage peroxide/hydrosulfite bleaching conditions and results are given in Table—6. The pulp was bleached to a ISO brightness of 70.2° in first peroxide stage and then bleached to 77—78° with 1.2% Na Hydrosulfite in the second stage, at a temperature of 70°C and bleaching time of 2 hrs.

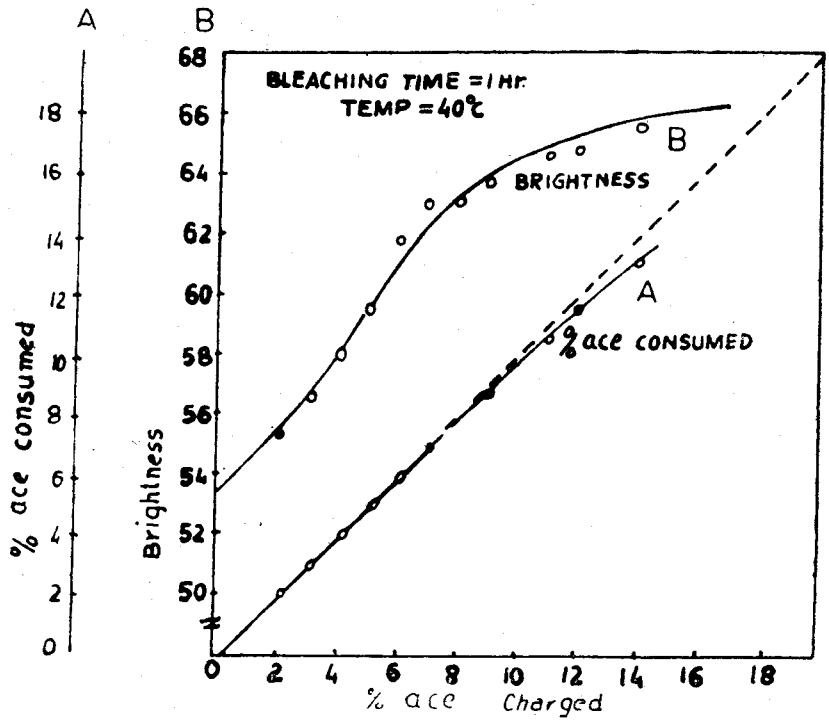

Fig. 1 HYPOCHLORITE BLEACHING OF KEORA CMP

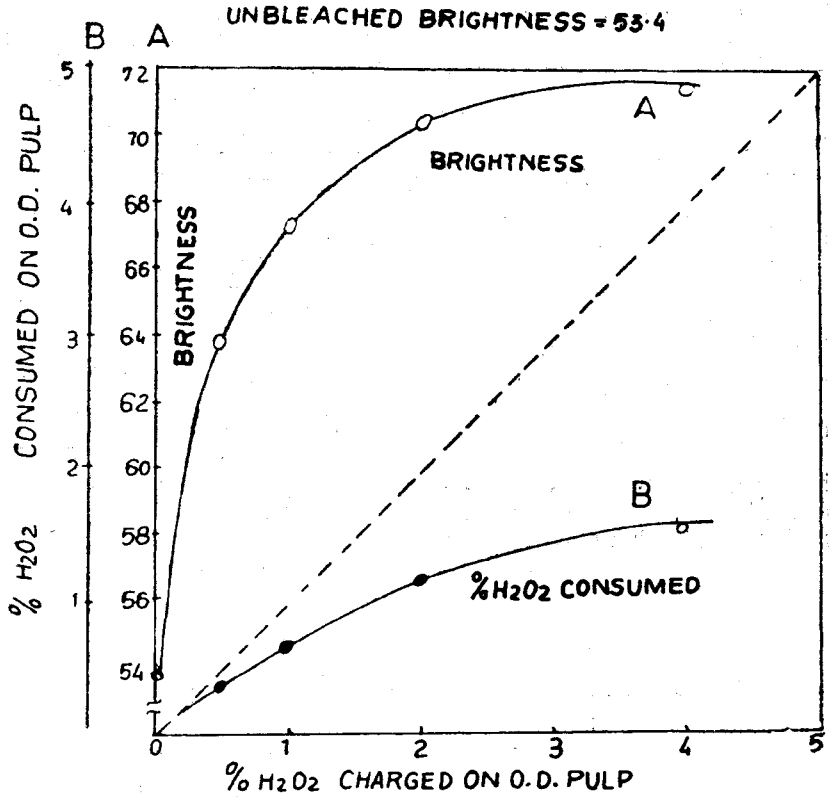

Fig.2-PEROXIDE BLEACHING OF KEORA CMP

Hypochlorite bleached pulp is used in the furnish of newsprint. 85% hypobleached pulp CMP (H) and 15% semibleached pine kraft is used as furnish and also 50% CMP (H) and 50% TMP is tried. The properties of hand sheets are given in Table—7. The properties of the paper produced on the pilot paper machine with the above furnishes are given in Table—8. It can be seen from the values that 85% CMP (H) and 15% SBK is a suitable furnish for the production of newsprint. The scattering coefficient is about 38 m^2/kg and opacity 90% with ISO brightness of 57° and sufficient strength for the runnability on paper machine. It also seems to be a possibility to eliminate the use of chemical pulp by using a furnish of 50% CMP (H) and 50% TMP. The brightness and opacity values are very good but the tensile index slightly lower but seems to be sufficient. The addition of little dye helped in avoiding the yellow look and added to opacity.

TABLE—8 PHYISCAL AND OPTICAL PROPERTIES OF MACHINE MADE NEWSPRINT

Furnish		85% CMP(H) 15% SBK	50% CMP (H) 50% TMP	
Basis Weight, g/m^2		50.2	45.8	53.5
Density, kg/m^3		518	471	466
Tensile Index	MD	67.1	49 2	49.1
KNm/kg	CD	32.5	25.4	26 5
Tear Index	MD	4.20	4.08	4.12
Nm^2/kg	CD	4.76	4 71	4 95
Brightness ISO		57.1	57.2	57.2
Y-Value		64.0	64.3	64.2
Opacity %		89 5	91 1	93.8
Scatt Coeff, m^2kg		37.8	46.9	46.7
Ruptured Load	MD	50.5	33.8	39.4
N/15 mm	CD	24.5	17.4	21.3

TABLE—9 PROPERTIES OF WRITING PAPER MADE ON PILOT PAPER M/C.

Furnish		80% EK 20% BK			80% CMP (P/HS) 20% BK			40 CMP (P/HS) 40% EK 20% BK		
% clay on O.D. Pulp		15	15	—	15	—	15	—	15	—	15
CODE		A 15	A 15 S	BO	B 15	BOS	B 15 S	CO	C 15	COS	C15 S
Basis Weight,		80.0	88.5	72.5	71 0	77.2	75.0	74 5	73.0	80.5	78.2
Density, Kg/m²		692	690	619	619	621	583	593	598	632	690
Tensile Index	MD	34.5	59.0	61.9	55.9	55.6	67.6	58.2	47.3	75.3	63.2
KNm/Kg.	CD	16.9	28.0	29.8	29.0	38 6	37 6	30 0	24.9	41.4	33.7
Tear Index	MD	6.61	6.20	5.88	5.46	5.59	5 28	6.98	6.85	6.35	6.20
Nm²/Kg.	CD	7.84	7.15	6.49	6.08	5.91	5.75	7.63	7.48	7.42	7.20
Ash Cantent, %		12.9	—	—	2.7	—	—	—	4 9	—	—
Wax Pick, Dennison		8	20	14	13	20	20	12	11	18	16
ISO Brightness		80.4	78.1	73.5	73.7	72.2	72.7	76.7	77.4	75.5	75.6
Opacity, %		91.3	90.9	89.9	90.0	89.1	88.7	89.3	90.0	88 3	88.3
Scatt. Coeff. m²/kg.		50.9	40 2	38.5	39.6	33.7	34.7	39.9	44 1	33.5	35.8

Three different furnishes were used for the production of writing paper on the paper machine : 80% BE and 20% BK ; 80% CMP (P/HS) and 20% BK; 40% CMP (P/HS), 40% EK and 20% BK. The hand sheets were prepared from these pulps and the properties are being given in Table—7. The properties of machine made papers from the above furnishes are given in Table 9. The following observations can be made after having a look on the results of Table 8 and 9 :

Conclusions :

From the present study, the following conclusions can be drawn :

— Keora responded well to the chemimechanical pulping. Approximate yield is 92% and the consumption of chemicals is low.

— The pulp was produced with an unbleached brightness of 50—53°. The cooking conditions can be so adjusted as to give the pulp of higher brightness (53—54°).

— The pulp can easily be bleached to a ISO brightness of 60 – 62°, with low consumption of hypochiorite (6—7% aCl) and therefore is suitable for use in the furnish of newsprint.

— The pulp can also be bleached to a brightness of around 70° in one stage peroxide bleaching using 2% H_2O_2. With two stage P/HS bleaching, it is possible to bleach it furher to a higher brightness if air can be avoided to mix with the pulp and sodium hydrosulfite during bleaching.

— Other papermaking properties, physical and optical, are quite acceptable for its use in the furnish of the above mentioned paper.

— CMP from Keora is a good pulp for its use in the furnish of newsprint of acceptable quality. It is also possible to use 50 : 50 (CMP and TMP) for the newsprint production if tensile can be further improved.

— CMP from Keora can be added in the furnish of writing paper. The cooking and refining conditions should be properly balanced. A good filler retentioa and surface sizing would

help in maintaining higher opacity and surface strength. It is therefore possible to make writing papers using 80% cold soda CMP from Keora.

The further investigation of this study can be carried out on bleaching of cold soda CMP keora pulp to a higher brightness by properly controlling the conditions during two stage peroxide/hydrosulfite bleaching. Such type of bleached pulps can be used in the furnish of papers of high commercial values.

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