Journal of the University of Chemical Technology and Metallurgy, 42, 1, 2007, 41-44

UTILIZATION OF VARIOUS CHEMICAL REAGENTS AND ADDITIVES FOR PRODUCTION OF CHEMICAL-MECHANICAL PULP FROM POPLAR WOOD

R. Boeva - Spiridonova, E. Petkova

University of Chemical Technology and Metallurgy
8 Kl. Ohridski, 1756 Sofia, Bulgaria
E-mail: r_boeva@abv.bg

Received 15 November 2006
Accepted 31 January 2007

ABSTRACT

The paper presents laboratory experiments for production of a chemical-mechanical pulp from poplar wood from the species ***Populus deltoids cultivar Onda*** *with increased density. In order in improve the desired parameters, various chemical reagents and additives (Na_2S_4 and H_2O_2) have been utilized. The study includes variations of the temperature, treatment time, type and quantity of the chemical reagent involved, and a study of the impacts of these factors on the physical and mechanical parameters of the fiber material produced.*

Based on the results obtained, an optimal regime for production of chemical-mechanical pulp from poplar wood with improved physical, mechanical and optical parameters was determined.

Keywords: chemical-mechanical pulp, production, poplar wood, application.

INTRODUCTION

The production of high yield fiber materials (HYFM) is related to higher wood utilization rate and the introduction of more environmentally sound technologies generating less pollution. These materials have found application in the production of different types of papers and cardboards [1]. The partial replacement of the expensive cellulose by high yield fiber materials in the production technologies for paper and cardboard is impossible without improving the processes for HYFM production. The poplar tree is a very valuable source of fiber materials. It is characterized by a high cellulose content and is easily impregnated with chemical reagents, which is explained by its high porosity and a relatively more uniform structure [2 - 4].

The aim of the present study is to find the optimal conditions for production of chemical-mechanical pulp from poplar wood through the use of various reagents and additives, and to determine their impact on the important physical and mechanical parameters of the fiber material obtained.

EXPERIMENTAL

Analytical measurements

The initial material for laboratory experiments is a poplar wood, species ***Populus deltoids cultivar Onda***, characterized by higher cellulose content, lower lignin content and higher density [4]. For production of chemical-mechanical pulp (CMP), chips with the standard size of 20x30x3 mm were used. The experimental conditions

Table 1. Conditions for production of chemical-mechanical pulp from poplar wood.

№	Type and input of chemical reagent, %	Treatment time, min	Temperature, ^oC	Yield, %
1	Na_2SO_3 – 5 Na_2CO_3 – 3	60	90	97.0
2	Na_2SO_3 – 5 Na_2CO_3 – 3	90	90	96.0
3	Na_2SO_3 – 5 NaOH – 3	180	90	94.0
4	NaOH – 10	120	90	89.6
5	NaOH – 7	120	90	92.8
6	NaOH – 7 Na_2SO_3 – 3	120	90	92.0
7	NaOH-7 H_2O_2-3, Na_2SiO_3-5 $MgSO_4$ – 0.05	120	90	92.0
8	NaOH – 7, Na_2S_4 – 0.5	120	90	91.0
9	NaOH – 7, Na_2S_4 – 1.0			92.3
10	NaOH – 7, Na_2S_4 – 2.0	120	90	91.8
11	NaOH – 7, Na_2S_4 – 3.0	120	90	91.0

Table 2. Physical, mechanical and optical properties of the chemical-mechanical pulp from poplar wood, produced at different conditions.

№	Tensile index, $N.m.g^{-1}$	Tear index, $m.N.m^2.g^{-1}$	Burst index, $N.m.g^{-1}$	Brightness, %	Yellowness, %
1	4.6	3.0	0.3	57.6	26.1
2	5.4	4.0	0.3	57.0	26.1
3	16.5	4.0	0.7	48.9	32.8
4	38.3	6.9	2.3	34.7	38.5
5	30.7	6.5	2.3	35.4	48.5
6	30.8	5.6	2.3	38.3	46.7
7	27.5	6.3	2.0	48.1	35.6
8	37.3	6.6	2.7	37.5	47.4
9	41.9	7.0	3.3	36.4	48.3
10	44.4	8.0	3.0	35.4	49.9
11	43.9	7.8	2.4	34.5	49.5

for the preparation of the fiber materials are presented in Table 1. For all experiments the liquor-to-wood ratio is 1:5. The treated chips have been refined in a Sprout-Valdron laboratory mechanical refiner up to 12 ^{0}SR. The produced CMP were milled separately in a laboratory Jokro mill up to 30 ^{0}SR [5]. The resultant physical, mechanical and optical characteristics are presented in Table 2.

The yield of CMP is calculated by the mass method. After soaking for 24 hours in distilled water, the treated chips were washed to neutral pH and dried into a drying apparatus at 105^{o}C to an achieve absolute dry state.

The bleaching effect of the treatments was determined with ELREPHO – 2000, by measurement of the diffuse blue reflectance factor (Bulgarian Standard for Brightness - ISO 2470). Determination of drainability was done by the Schopper-Riegler method - Bulgarian Standard ISO 5267-1, the determination of the bursting strength (Bulgarian Standard ISO 2758) on Schopper – Daalen, and the determination of tearing resistance –

by the Elmendorf – Bulgarian Standard ISO 1974. The determination of the tensile properties was performed according to part 2, constant rate of elongation method of the Bulgarian Standard ISO 1924 – 2. Samples characterized by 75g.m^{-2} (ISO 536:1998) were cast out [6].

RESULTS AND DISCUSSION

The application of Na_2SO_3 and Na_2CO_3 (Trials 1 and 2) leads to production of fiber materials with a high 96 – 97 % yield, but lower physical and mechanical parameters. The prolongation of the treatment time from 60 to 90 min does not help to improve the target parameters. The fibers are coarse, non-elastic and not capable to create sufficient number of connections between each other during the casting out of the paper sheets. Under the selected conditions of trials 1 and 2 (Table 1) the process of lignin's sulphonation occurs in a lowe degree. Probably the lignin is not well plastified and stays absolutely unchanged in the fiber material, as proven by the high yield. The *brightness level* is relatively high – 57 %. The replacement of Na_2CO_3 with NaOH (Trial 3) leads to an increase in the *break index* and reduction of the yield by 2 %, however the total physical and mechanical properties (FMP) remain low.

Therefore, several experiments with NaOH have been performed. The wood swells up in alkaline liquids, the lignin is modified and plastified well. The reactions between the wood components (lignin, chemicellulose materials) and the alkaline agents occur at temperatures below 100°C. The resultant physical and mechanical properties significantly improve. The chemical treatment in alkaline conditions allows for further mechanical impact caused by milling through the refiner, partial fibrilization of the fibers and production of stronger connections, when the paper sheet is formed.

Further trials have been performed in order to find out the optimal level for utilization of NaOH. The input rate of 10 $\%_{dry\ mass}$ and 7 $\%_{dry\ mass}$ NaOH, calculated from the mass of the absolutely dry wood, was investigated (Trials 4 and 5). The data given in Tables 1 and 2 indicate that an increased input of NaOH 10 $\%_{dry\ mass}$ leads to production of a chemical-mechanical pulp with better characteristics. But the analyses of the residual liquor shows that only 60 % of the input alkaline reagents have reacted. The yield is diminished to 89 % that is unfavorable from an economic point of view.

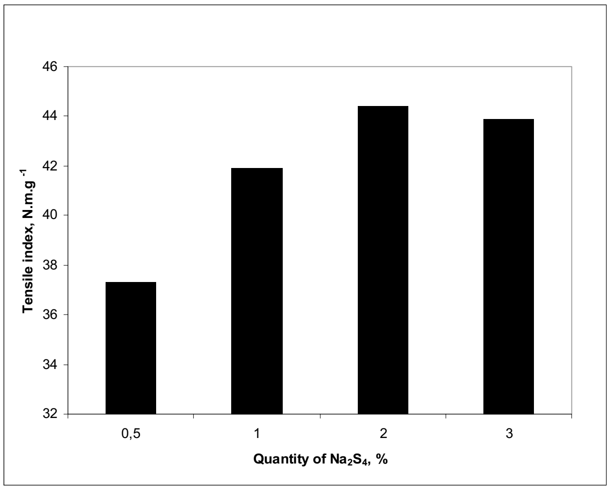

Fig. 1. Influence of the quantity of Na_2S_4 on the tensile index.

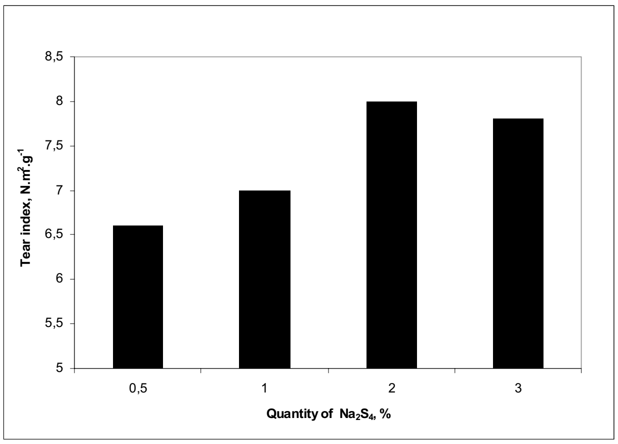

Fig. 2. Influence of the quantity of Na_2S_4 on the tear index.

The use of 3 $\%_{dry\ mass}$ Na_2SO_3 (Trial 6) leads to increase in the whiteness level with about 2 – 3 %. Trial 7 provides interesting results for the use of 2 % H_2O_2 as an additive with the main purpose to produce fiber materials with a better whiteness level. The brightness level reached up to 48.1 %. Na_2SiO_3 and $MgSO_4$ have been used as stabilizers into the peroxide solution.

With the major objective to improve the pulp performance and to keep the yield at high rates, Na_2S_4 was added to the examined solution. It is well known that Na_2S_4 acts as a stabilizer of the wood carbohydrate components. It is effective at temperature about 120°C, but becomes instable if the temperature is further increased.

Different quantities (0.5 $\%_{dry\ mass}$, 1.0 $\%_{dry\ mass}$, 2.0 $\%_{dry\ mass}$ and 3.0 $\%_{dry\ mass}$) Na_2S_4, were used. The yields, and the physical and mechanical properties of the obtained fiber material are given in Tables 1 and 2.

The input of Na_2S_4 leads to an increase in the physical and mechanical properties. The other results are associated with the introduction of 2.0 $\%_{dry\ mass}$ additive. The tensile index reaches about 44.0 $N.m.g^{-1}$, while the yield is 91.8 %. If the additive quantity is raised 3 %, the yield and the tensile index start to diminish. This is graphically represented in Figs. 1 and 2.

The experimental results clearly indicate that the optimal conditions for production of a chemical-mechanical pulp from poplar wood are: chemical reagent input – 7 % NaOH, additive – 2 % Na_2S_4, temperature - 90 ^{o}C and chemical treatment duration 120 min.

CONCLUSIONS

CMP using different chemical reagents is obtained. The influence of Na_2S_4 and H_2O_2 results in fiber materials with good physical, mechanical properties and optical properties. Various chemical reagents have been applied and it was found that the input of 2 $\%_{dry\ mass}$ Na_2S_4 allows for production of high-yield chemical-mechanical pulp with good physical and mechanical properties. The better parameters of the newly obtained pulp provide grounds for its further successful utilization in the composition of different papers, meanwhile realizing economy of bleached and unbleached pulp from softwood and hardwood.

REFERENCES

1. V. E. Shamko, “High Yield Polyproducts”, Moscow, “Forest Manufactures”, 1989, (in Russian).
2. Z. Litovski, R. Boeva, E. Petkova, The new trends by high yield fiber materials production, Cellulose and Paper, **2**, 2001, 6 – 8, (in Bulgarian).
3. E. Petkova, R. Boeva, Z. Litovski, Izsledvane vazmojnostite za poluchavane na himiko-mechanichna masa ot topolova darvesina, Paper and cellulose, **3**, 2001, 7-8, (in Bulgarian).
4. V. Kirov, Z. Litovski, Himichna i fizichna harakteristika na topolovata darvesina ot italianskite vidove, Gorsko stopanstvo, 2, 1988, (in Bulgarian).
5. ISO 5267-1:1979.
6. ISO 536-1998.