ALKALINE PULPING OF RAPESEED STRAW

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Abstract

In this paper, the suitability of rapeseed straw for cellulosic fibre production under convectional soda pulping process was examined. The pulping results were obtained for stalks of rapeseed straw and for rapeseed straw comprising stalks and valves of siliques. Both the total yield and kappa number of pulp drop with increasing H-factor which is directly proportional to cooking time. The addition of anthraquinone to cooking liquor led to a significant decreasing in total yield and kappa number characterizing a degree of delignification of pulp. It is worth mentioning that the presence of anthraquinone had a positive effect on decreasing in amount of rejects, mainly at lower values of H-factor up to 1 500 h.

Keywords: *rapeseed straw; delignification; soda pulp; anthraquinone*

Introduction

In many countries where wood is not available in sufficient quantities, one alternative to replacing short wood fibres for printing papers is to use of non-wood fibres from annual plants or agricultural residues.

The most commonly used commercial method in pulping of non-woody species is still soda process using sodium hydroxide as the cooking chemical. Addition of anthraquinone (AQ) to cooking liquor not only can affect pulp yield, it also can increase the rate of delignification leading to lower lignin levels for equivalent cooking conditions. In the past decade, the soda-AQ process has been utilized to produce pulps from kenaf bark [1], okra stalks [2], weed (*Ipomea carnea*), and hemp [2], amaranth, orache, and Jerusalem artichoke [3], industrial grass [4], bamboo [5], dhaincha (*Sesbania aculeata*) [2,6], and rice straw [7]. Using conventional soda process without anthraquinone addition, pulps have been produced from cannola stalks [8], and rapeseed straw [9] as well.

The objective of this paper was to conduct batch soda pulping of rapeseed straw and to investigate the effect of anthraquinone addition on the degree of delignification. For rapeseed straw formed from stalks and valves of siliques and for stalks only as a pulping material, the dependencies of the total yield and kappa number upon H-factor were evaluated. Thus, this study continues in investigation of chemical pulping of rapeseed straw and extends the results on soda pulping reported in the previous work [9] over the area of soda pulping with anthraquinone as a catalyst of delignification.

Experimental

Rapeseed straw (*Brassica napus* L. convar. *napus*, in our case linie genotype Labrador) collected from the field in Polabian lowlands near the city of Pardubice was used for the pulping process. Raw materials consisted mainly of stalks, but approximately one third of total amount were valves of siliques.

Prior to cooking experiments, the rapeseed straw was cut into 2–3 cm length chips. The moisture content of straw was within 6 and 10 %, depending on the relative humidity of air. Soda and soda-AQ pulping of rapeseed straw was carried out in a laboratory rotary digester comprising six autoclaves of 750 cm^3 capacity, immersed in an oil bath. The batch cooks giving pulps to produce handsheets were performed at the liquor-to-raw material ratio kept at 5:1, alkali charge of 19 % expressed as Na_2O per o. d. raw material, and cooking temperature of 160 °C. When anthraquinone was added to cooking liquor, its charge was 0.1 % per o. d. raw material. The temperature regime was as follows: 45 min heating to 105 °C, 30 min dwelling at 105 °C, 30 min heating to 160 °C, and then dwelling at cooking temperature. The batch cooks were ended as soon as the H-factor reached a value from 500 to 2 600 h. The corresponding pulping time at cooking temperature varied from 40 to 220 min.

After the cooking process, the cooked pulp was refined, thoroughly washed with tap water, and screened using 10 mesh sieve. The kappa number of the pulp obtained after screening was determined in accordance with the TAPPI Test method T 236 om-99.

Results and Discussion

The extent of delignification reaction was characterized by the H-factor which is a cooking variable that combines cooking temperature and time into a single variable. This variable is often used for comparison of the cooks of varying reaction time and temperature [9].

In Figure 1, the results obtained for rapeseed straw and stalks only are compared. As would be expected, the total yield, as well as the kappa number decrease with increasing H-factor within the limits of 860 h to 2 580 h. Nevertheless, H-factor influenced the total yield for stalks much markedly than for rapeseed straw. It has to be reminded that random samples of straw containing different amounts of stalks having various diameters were inserted into digester vessels. This fact could influence the dependencies of the total yield determined experimentally. The lower total yield obtained for straw in comparison with stalks can be ascribed to the presence of valves of siliques having lower content of cellulose. Valves of siliques formed approximately one third of the straw mass.

It must be stressed that, for a more synoptical comparison of dependencies showed in Figure 1 thin lines were inserted between points. In any case, these lines do not express courses of given variables between discrete values obtained experimentally.

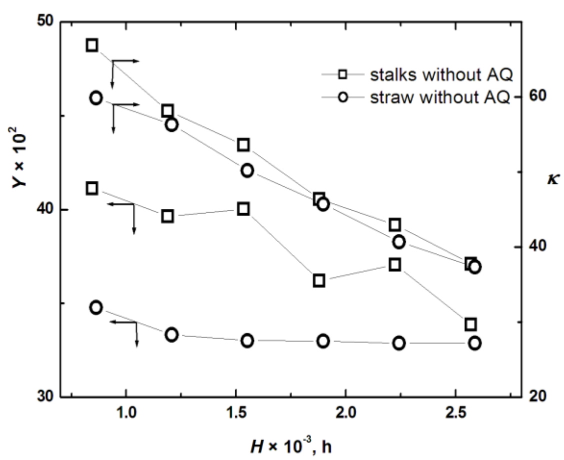

Figure 1. Total pulp yield, Y, and kappa number, κ, as a function of H-factor for soda pulps from stalks and rapeseed straw.

The effect of the presence of anthraquinone in the cooking liquor upon soda cooks for stalks is demonstrated in Figure 2. The addition of AQ in the amount of 0.1 % on o. d. raw material led to considerable changes in the total yield and kappa number. It confirmed that anthraquinone in the cooking liquor accelerates delignification reaction.

While with increasing H-factor the kappa number dropped from 66 to 38 for cooking liquor without anthraquinone, the anthraquinone addition led to substantial decrease in kappa number ranging within the limits of 22.7 to 16. At the same time, the difference in the kappa number decreased with increasing H-factor. While for H-factor of 860 h the kappa number decreased by 43 points, the decrease in kappa number by 22 points was attained for H-factor of 2 590 h. The presence of anthraquinone influenced the total yield as well. For soda cook without

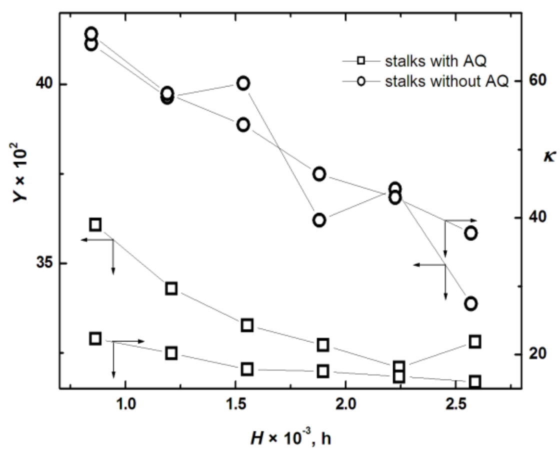

Figure 2. Total pulp yield, *Y*, and kappa number, *κ*, as a function of H-factor for soda and soda-AQ pulps from stalks.

anthraquinone, the total yield dropped in the range of 41 % to 34 % with increasing cooking time. However, in the case of anthraquinone presence in cooking liquor, the total yield decreased from 36 % to 32.5 %. Thus, with increasing H-factor, the difference in the total yield decreased from 5 % at H-factor of 860 h to 1.5 % at H-factor of 2 590 h.

It is worth mentioning that the stalks without valves of siliques gave greater total yield in comparison with a blend of stalks and valves of siliques. The kappa number decreased with increasing H-factor for both raw materials tested. In contract to cooking without anthraquinone, the kappa number for pulp from rapeseed straw is greater in comparison with pulp produced from stalks.

Conclusion

Rapeseed straw can be thought as one of possible sources of short fibre pulp, mainly in the regions suffering a lack of hardwoods. Pulp fibres manufactured from rapeseed straw are short with average length less than 1 mm (the weighted average length of 0.84 mm). The lignin content of rapeseed straw is comparable with that of hardwoods. Owing to relatively great solubility of rapeseed straw in alkaline solutions, the lower yields after soda pulping can be achieved.

Adding anthraquinone to cooking liquor brings the greater rate of delignification. At given H-factor, the soda-AQ pulping provides pulp cooked to lower kappa number, containing lower amount of rejects, but also a decrease in total yield must be taken into account.

The presence of valves of siliques in straw leads to lower pulp yield and has also a negative impact on strength characteristics of pulp. The breaking length of beaten rapeseed straw pulp (≈ 5 km) seems to be greater than that of waste paper (≈ 4 km), but lower in comparison with unbleached softwood kraft pulp (≈ 8 km).

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Abstrakt

Cílem práce bylo uskutečnit diskontinuální alkalické várky slámy řepky olejky bez a s přídavkem antrachinonu do varného louhu. Větší celkový výtěžek a kappa číslo byly dosaženy pro buničinu uvařenou pouze ze stonků ve srovnání s buničinou získanou ze směsi stonků a šešulí. Přídavek antrachinonu do varného louhu se promítl do snížení výtěžku a kappa čísla v celém proměřeném rozsahu H-faktoru. Rovněž se snížilo množství neprovarů v uvařené buničině, a to zejména u buničiny uvařené při H-faktoru menším než 1 500 h.