INFLUENCE OF ANTHRAQUINONE ON ALKALINE PULPING OF RAPESEED STRAW

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Abstract

The objective of this work was to determine the potential application of rapeseed straw in the soda pulping process and to investigate the effect of some cooking variables, such as active alkali (AA) charge, liquor-to-straw ratio and anthraquinone (AQ) charge, on the total pulp yield, amount of rejects and kappa number of the pulp. The results obtained showed that the liquor-to-straw ratio of 5, active alkali charge of 19 % and anthraquinone charge of 0.02 % were sufficient to achieve a pulp containing low amount of rejects.

Keywords*: alkaline pulping, rapeseed straw, anthraquinone*

Introduction

Factors like population growth, better literacy, development of communication and industrialization in developing countries, have led the world to the huge consumption of paper and board products continuously. In order to fulfill the needs of alternative fiber source, paper production facilities have been forced to utilize uncommon raw materials, especially non-wood fibers. Due to its abundance and cost effectiveness, it has become reasonable source of fibrous raw material to pulp and paper industries [1]. The production of non-woody plants pulps has increased more rapidly and nowadays, several non-wood fiber resources are commercially utilized to manufacture chemical pulp and paper products in China, India, Latin America, Africa, Middle East and Turkey [2]. Non-woody pulp has been utilized for the production of common, writing and printing, as well as specialty papers such as filter, cigarette, bible, currency, etc. [3].

Among non-woody plants, rapeseed is one of the possible sources. Basically, it is planted for edible oil production but its uses expand to biodiesel applications as well. Moreover, its range of applicability can be extended as one of the source of annual non-wood fiber materials that can address the needs of pulp and paper industry.

Hence, the objective of this work was to prepare pulp from rapeseed straw by soda cooking and to investigate the effects of cooking variables, such as liquor-to-straw ratio, AA charge, and AQ charge, upon the total pulp yield and degree of delignification expressed by a kappa number of the pulp and also by an amount of rejects.

Materials and Methods

Rapeseed straw (*Brassica napus* L. convar. *napus*, in our case genotype Labrador) collected from the field in Polabian lowlands near the city of Pardubice was used for soda cooking. Fine mass of stalks with varying diameter was obtained separating the valves of siliques, debris and leaves from rapeseed straw.

Soda pulping runs were conducted in 6 batch reactors, each with capacity of 750 cm^3, immersed in a silicon oil bath in a digester. Cooking of raw material was performed in such a manner: 45 min heating to 105 ˚C, 30 min dwelling at a temperature of 105 ˚C for impregnation, 30 min heating to a cooking temperature of 160 ˚C and dwelling at it. As soon as the H-factor reached a desired value, the cooking was stopped. After separating the black liquor by pressing, the cooked pulp was subjected to defibrillation in a laboratory slusher. Then, the pulp was thoroughly washed with tap water in four dilution/dewatering stages and screened using 10-mesh plastic sieve. The rejects held on the sieve were separated manually. 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 influence of the AA charge ranging within the limits of 0.17 to 0.21 g of Na_2O per g of oven-dry straw on the kappa number and amount of rejects expressed as a mass fraction of cooked pulp is illustrated in Fig. 1. In all runs, the liquor-to-straw ratio was kept at 7.

The kappa number shows similar trend like the total amount of rejects with increasing AA charge. With increasing AA charge, both kappa number and amount of total rejects decrease (Fig. 1). The reduction in kappa number indicates the higher rate of delignification. The results from soda cooking showed that the highest amount of total rejects of 7.7 % is obtained at cooking conditions of 17 % AA charge and a liquor-to-straw ratio of 7. It must be stressed that, for a more synoptical comparison of dependencies showed in Fig. 1 (also in Figs 2–3), thin lines were inserted between points. In any case, these lines do not express courses of given variables between discrete values obtained experimentally.

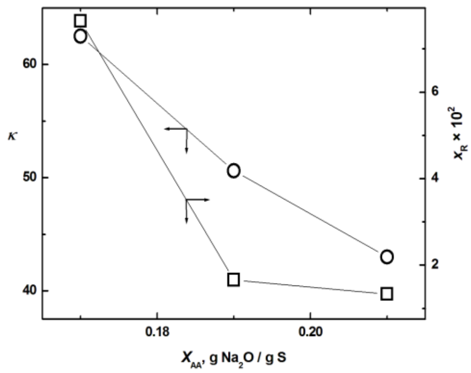

Figure 1. Total rejects, x_R, and kappa number, κ, as a function of AA charge.

The effect of the liquor-to-straw ratio ranging from 5 to 9 upon the kappa number and amount of reject was investigated at an AA charge of 0.19 g of Na_2O per g of oven-dry straw. The kappa number increased with increasing the liquor-to-straw ratio. Similarly, the amount of total rejects increases with increasing liquor-to-straw ratio. With respect to decreasing driving force, which decreases how the cooking liquor is more dilute and the concentration of active alkali drops, the degree of delignification decreases with increasing the liquor-to-straw ratio. It is worth mentioning that, in comparison with wood chips, the liquor-to-raw material ratio is greater in the case of light bulky materials like straw. For example, the liquor-to-straw ratio of 8 and 10 was reported for canola straw pulping [4] and organosolvent pulping of amaranth, lavatera, sverbiga, and schavnat [5], respectively.

The results also showed that the rapeseed stalks cooked at a liquor-to-straw ratio of 7 and 17 % AA charge give the highest total yield of 40.9 %, whereas the lowest yield of 26.4 % is found for the rapeseed stalks cooked at 21 % AA charge and a liquor-to-straw ratio of 7. The total pulp yield of 37.1 %, kappa number of 38.3 and amount of total rejects of

1.1 % were reported for rapeseed straw cooked at an AA charge of 17 %, a liquor-to-straw ratio of 5 and an H-factor value of 1,600 h by Potůček and Milichovský [3].

On the basis of the preliminary results, further pulping runs were carried out at an AA charge of 0.19 g of Na_2O per g of oven-dry straw and a liquor-to-straw ratio of 5. Under these conditions, the influence of the AQ charge ranging from 0 to 0.1 %, based on oven-dry straw, upon the total yield and degree of delignification was investigated.

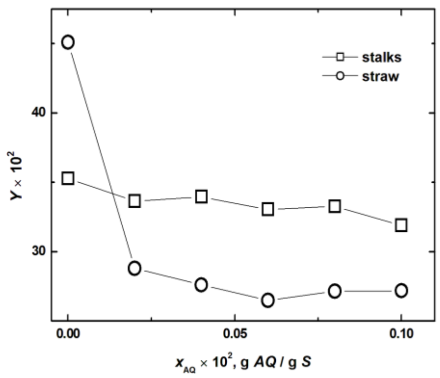

Figure 2. Dependence of total yield, *Y*, on AQ charge.

From the comparison of the dependencies of the total yield and amount of total rejects on the AQ charge for both raw materials, rapeseed straw and stalks only, it follows that an increase in the AQ charge causes a decrease in the total yield, as well as in total amount of rejects, as illustrated in Figs 2 and 3, respectively. The total yield is higher for 0 % AQ charge and lower for higher dosages of anthraquinone. However, for pulp cooked from stalks only, the difference in total yield with AQ charge ranging from 0.02 % to 1 % is not so substantial. The total yield at 0 % AQ charge is of 35.26 % and at 0.1 % AQ charge is of 31.88 %. For comparison, soda-AQ pulp yield of 27.7 % for Jerusalem artichoke, 34.4 % for amaranth and 37.7 % for orache were reported by Fišerová *et al.* [6], while Mohta *et al.* [7] reported the soda pulp yield of 53.6 % and soda-AQ pulp yield of 50.3 % for depithed bagasse using 12 % sodium hydroxide and 0.1 % AQ charge.

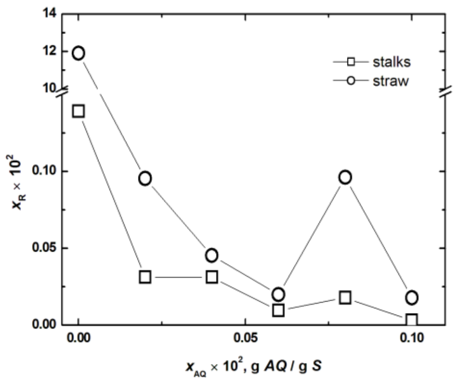

Figure 3. Dependence of amount total rejects, x_R, on AQ charge.

As illustrated in Fig. 3, the amount of total rejects has a decreasing trend with increasing dosage of anthraquinone. Similarly, the kappa number decreases as the AQ charge increases. It could be attributed mainly to higher rate of delignification in the presence of anthraquinone. For stalks, the kappa number was found to be 33.36 at 0 % AQ charge, whereas at 0.1 % AQ charge, it is of 16.41 only. The kappa number decreased as the AQ charge increased for both raw materials tested. Nevertheless, it was observed that the drop in kappa number is less steep within the interval of 0.02 to 0.1 % AQ charge. In comparison with soda pulping, the presence of anthraquinone decreases the kappa number and also the amount of rejects with all AA charges, however, the yield is slightly lower as well.

Conclusion

The presence of anthraquinone in the cooking liquor had unambiguously a positive impact upon the rate of delignification. Anthraquinone addition led to a decrease in the amount of rejects and kappa number of pulp cooked at a desired H-factor. On the other hand, the total yield of pulp cooked at a presence of anthraquinone was lower in comparison with soda pulping without anthraquinone. The amount of total rejects and kappa number were found to be higher for a blend of stalks and valves of siliques in comparison with cooking of stalks only. The results obtained for anthraquinone application in soda pulping showed that 0.02 % of anthraquinone based on o. d. straw appears to be sufficient to achieve favorable decrease in amount of rejects and kappa number of pulp.

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References

[1.] HOSSEINPOUR, R. and LATIBARI, A. J. *The papermaking potential of canola residues; viable raw material*. In Proceedings of the 55th International Convention of Society of Wood Science and Technology, 2012, August 27 – 31, Beijing, China.

[2.] TUTUS, A., EZICI, A. C. and ATES, S. *Chemical, morphological and anatomical properties and evaluation of cotton stalks (Gossypiumhirsutum l.) in pulp industry*. Scientific Research and Essays, 2010, vol. 5, pp. 1553 – 1560.

[3.] POTŮČEK, F. and MILICHOVSKÝ, M. *Rapeseed straw as possible source of non-wood fiber materials*. Cellulose Chemistry and Technology, 2011, vol. 45, no. 1 – 2, pp. 23–28.

[4.] ENAYATI, A. A., HAMZEH, Y., MIRSHOKRAIE, S. A. and MOLAII, M. *Papermaking potential of canola stalks*. BioResources, 2009, vol. 4, pp. 245 – 256.

[5.] BARBASH, V., POYDA, V. and DEYKUN, I. *Peracetic acid pulp from annual plants.* Cellulose Chemistry and Technology, 2011, vol. 45, no. 9 – 10, pp. 613 – 618.

[6.] FIŠEROVÁ, M., GIGAC, J., MAJTNEROVÁ, A. and SZEIFFOVÁ, G. *Evaluation of annual plants (Amaranthuscaudatus L., Atriplexhortensis L., Helianthustuberosus L.) for pulp production*. Cellulose Chemistry and Technology, 2006, vol. 40, no. 6, pp. 405 – 412.

[7.] MOHTA, D., UPADHYAYA, J., KAPOOR, S., RAY, A. and ROY, D. *Oxygen deligninfication of soda and soda-AQ bagasse pulps*. Tappi Journal, 1998, vol. 81, no. 6, pp. 184 – 187.

Abstrakt

Cílem práce bylo uskutečnit diskontinuální alkalické várky slámy řepky olejky za různých varných podmínek. V první části práce byl vyšetřován vliv zanášky aktivních alkálií do varného louhu a hydromodulu zejména na kvalitu uvařené buničiny vyjádřenou stupněm delignifikace a množstvím neprovarů. Jako nejvhodnější se jevila zanáška alkálií 19 % a hydromodul rovný 5. Druhá část práce byla věnována sledování vlivu zanášky antrachinonu na celkový výtěžek a kappa číslo uvařené buničiny. Dosažené výsledky ukázaly, že dostatečná zanáška antrachinonu je 0,02 %.