Study of Chemical Kinetics of Kraft Delignification of Eucalyptus Teriticornis & Validity of H-Factor

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In view of increasing consciousness about quality of paper and paper products in demand, the attention of paper technologists in the country has been diverted to evolve the technology for producing high yield pulps without sharing it's physical and chemical properties. In this direction an initiative has already been taken by Vroom in 1957, who introduced H-factor as one single variable in place of two cooking variables namely time and temperature. Based on this idea the validity of H-factor in delignification of Bamboo by Kraft process, and Eucalyptus wood by N.S.S.C. pulping process has already been studied at the laboratories of Cellulose and Paper Branch, Forest Research Institutes and Colleges, Dehradun and I.I.T. Bombay.

The characteristics of lignin, present in bamboo and hardwoods is quite different and therefore it has been felt necessary to carry out exhaustive study of kinetics of delignification in sulphate pulping of eucalyptus hybrid which may become a major raw material in the years to come.

In the present work, the eucalyptus hybrid has been cooked by sulphate process with 16% active alkali as Na_2O and at cooking temperatures varying from 100°C to 180°C and cooking time varying from zero mts to 210 mts. The sulphidity of cooking liquor was almost kept constant at about 20%. The un-bleached pulps were analysed for lignin and carbohydrate contents, and also their Kappa No. and yield were determined. The rate of reaction was calculated by plotting cooking time Vs. residual lignin in pulp and then order of reaction was found out from the graph, Log. reaction rate Vs. Log residual lignin, which gave almost a straight line, confirming that the delignification of eucalyptus hybrid is a first order reaction. But the reaction constants calculated from first order rate expression indicated that it is higher than first order, and therefore, it may be assumed that rate of delignification of eucalyptus is of pseudo first order reaction. The energy of activation has also been calculated to be 33000 calories/mole which is slightly higher than the value assumed for kraft pulping. Based on this value of energy of activation the constants A & B were calculated to be 16610 and 44.5 respectively. Thus relative reaction rates at various temperatures have been calculated which are slightly different than those calculated for sulphate pulping due to pseudo first order reaction.

Now attempt has been made to establish the suitability of H-Factor concept as a control in kraft pulping. For this purpose a standard cook at 170°C for 90 mts at cooking temperature was carried out, and it's H-Factor was calculated mathematically and graphically as well. Finally cooks were carried out at 160, 165, 175, and 180 °C for predicted cooking time, maintaining H-Factor constant. The yield and Kappa No. of unbleached pulps were found out, and also pulps were analysed for lignin and carbohydrate contents. From the results it may be concluded that the quality of pulp remains almost same at constant H-Factor. Therefore H-Factor may be used as a Control for delignification of cellulosic material by any pulping process, carried out in batch or continuous digesters.

It may also be mentioned that the technology has advanced to an extent that pulp yield, effective alkali, sulphidity, Kappa No. and H-Factor, may be expressed by a single equation, $Y=A+B\ (\ln H\ (EA)^n)$ which would be of great help in quality control. Similarly the variables involved in carbohydrate dissolution reaction are also expressed by a single expression known as Q-Factor. The Q-Factor is a differential equation that incorporates carbohydrate concentration, liquor strength, a carbohydrate reaction velocity constant, and temperature. Therefore fundamental study in this direction should be taken up for our raw materials, namely bamboo and eucalyptus.

First order rate constants of delignification reaction

S.No.	*Temperature °K*	*Rate constants ($Hour^{-1}$)*
1.	443	1.2
2.	438	0.7416
3.	433	0.4971

Temperature coefficient of delignification reaction.........2.41

Energy of activation of delignification reaction (Calories/mole) 33,000

Arhenious first order rate expression for kraft delignification of eucalyptus hybrid :

$$Ln\ K=44.5-16610/T$$

Relative reaction rates

S. No.	*Temperature °C*	*Relative rate*
1.	100	1
2.	110	3
3.	120	9.5
4.	130	26
5.	140	72
6.	150	187
7.	160	465
8.	170	1096
9.	180	2588
10.	190	5534