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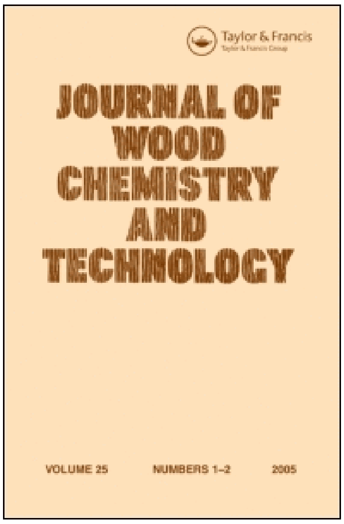

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Viscosities of Unbleached Alkaline Pulps. III. Wood Species

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VISCOSITIES OF UNBLEACHED ALKALINE PULPS. III. WOOD SPECIES.

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ABSTRACT

A variety of hardwoods and softwoods were cooked under identical conditions (constant alkali charge, temperature and time) and yielded pulps of widely varying Kappa number but essentially constant viscosity. Wood species is therefore not a significant factor in determining the viscosity of unbleached pulp. This observation indicates that the G-factor equation for viscosity prediction (so far examined only for spruce) may have a wide applicability.

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We reported previously that the delignification accelerators, anthraquinone (AQ) and sodium sulphide, have no effect upon pulp viscosity provided that the cooking parameters (effective alkali charge (EA), cooking time and temperature) are held constant[1]. We also measured the activation energies for viscosity loss in alkaline cooking and found that, again, AQ and sulphide have no influence[2]. The viscosity of unbleached pulp was found to be determined by only 3 parameters: the effective alkali charge, the cooking time and the temperature. Of these, the alkali charge was the most important factor. The work referred to above[1,2] was, however, confined to black spruce.

In this report we describe the kraft pulping of a number of different wood species with a range of alkali charges, other conditions being fixed. The Kappa numbers of the resulting pulps

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were distributed over a wide range. This type of pulping differs from that normally practised where a target Kappa number is sought. In conventional pulping, hardwoods are always cooked with a relatively low alkali charge because, compared to softwoods, they are easy to delignify. Consequently, it is never possible to tell whether the high viscosity pulps obtained from hardwoods (especially aspen[3]) are due to inherently different cellulose, or whether they are due to the decreased hydroxide ion concentration.

RESULTS AND DISCUSSION

When cooked with a fixed alkali charge and H-factor, hardwoods and softwoods produced pulps of similar viscosity* but with a wide range of Kappa numbers (Figure 1, Table I). At a charge 13.1% EA, for example, all wood furnishes gave pulp of viscosity 53.6 ±4 mPa.s although Kappa numbers ranged from 11 (aspen) to 76 (balsam fir). The pulp viscosity was strongly dependent on the alkali charge, but not on the wood species. There was more scatter in the viscosity data at the highest viscosities (lowest alkali charges). This is to be expected, since the repeatability of the viscosity test is given as ±4% of the mean value[5].

The residual effective alkali in the spent liquor from red cedar was consistently low: about 3 g/L below the mean value for other softwoods. Horng and Krasnowski noted[6] that red cedar required more alkali than other softwoods for delignification to a target permanganate number. Whatever the reason for the alkali consumption, the red cedar cellulose was exposed to a lower average alkali charge than was the cellulose of the other wood species. It is therefore not surprising to find (Table I) that the viscosity of the cedar pulp was consistently above the mean. In retrospect it seems that the standard deviation of the viscosity data might have been less had the experiment been designed to allow for different acidities in the wood

* All the pulps were subjected to acid-chlorite delignification[4] prior to preparation of the 0.5% cuene solution.

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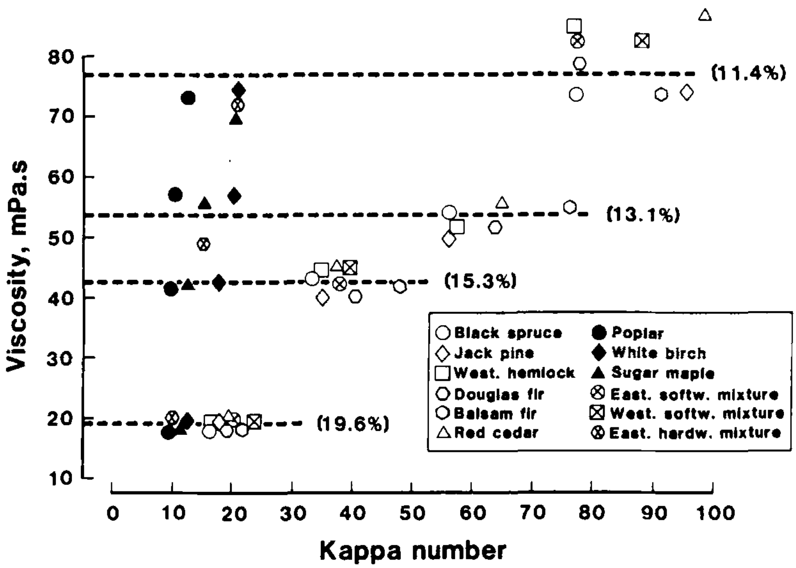

FIGURE 1. Viscosity is plotted against the Kappa number of kraft pulp from numerous wood species cooked at the same H-factor and several different effective alkali levels (figures in parentheses).

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furnishes. One way to do this is to keep constant not the applied effective alkali, but the effective alkali measured at the end of the rise-to-temperature ($EA_{170°}$). This type of control strategy[7,8] is in commercial use with batch digester systems[9,11]. Work now in progress is designed to correlate pulp viscosity with initial effective alkali concentration, and with $EA_{170°}$ values. The correlation coefficients so obtained should demonstrate which parameter relates better to pulp viscosity.

CONCLUSION

The observations presented in Figure 1 and in Table I indicate that the cellulose molecule behaves much the same in alkaline pulping regardless of whether it derives from hardwoods or softwoods. This fact is normally disguised by the different pulping conditions which are needed to achieve adequate delignification. The high vis-

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TABLE I
Pulping Conditions and Pulp Quality

Wood Species	11.4% E.A., 25% Sulphidity			13.1% E.A., 25% Sulphidity			15.3% E.A., 30% Sulphidity			19.6% E.A., 30% Sulphidity		
	Total Pulp Yield % on O.D. Wood	Kappa No.	Viscosity, mPa.s	Total Pulp Yield % on O.D. Wood	Kappa No.	Viscosity, mPa.s	Total Pulp Yield % on O.D. Wood	Kappa No.	Viscosity, mPa.s	Total Pulp Yield % on O.D. Wood	Kappa No.	Viscosity, mPa.s
Black spruce	54.3	77.2	73.4	50.0	56.3	54.0	48.6	33.8	43.3	42.8	16.1	17.8
Jack pine	51.3	95.4	73.8	45.9	55.9	59.8	44.4	34.8	39.7	41.7	17.7	19.6
Western hemlock	54.9	76.8	84.8	51.0	57.6	51.9	48.4	34.7	44.6	44.1	16.9	18.5
Douglas fir	51.3	77.7	78.5	45.9	63.8	51.5	42.1	40.4	40.1	38.4	19.5	18.2
Balsam fir	54.6	91.3	73.2	53.5	76.2	54.8	48.2	48.0	41.8	45.2	21.8	18.5
Red cedar	47.1	98.4	86.9	45.2	64.8	55.6	40.8	38.0	45.1	37.6	18.1	20.3
Poplar	55.8	12.6	73.0	55.4	10.6	57.0	52.1	9.4	41.1	51.2	9.4	18.0
White birch	54.8	21.0	74.6	52.7	20.2	57.0	52.4	17.8	42.5	48.0	12.7	19.7
Sugar maple	43.4	20.6	69.8	49.3	15.5	55.9	46.5	12.6	42.0	43.4	10.6	17.9
Eastern softwood mixture	52.6	77.4	77.5				47.0	37.9	42.2	44.0	19.8	19.5
Western softwood mixture	50.8	88.1	82.6				45.8	39.4	45.0	41.9	23.3	19.8
Hardwood mixture	54.2	20.8	74.8	51.8	15.3	48.9		–	–	48.7	10.8	20.2
Mean Viscosity			76.9			53.6			42.5			19.0
Standard Deviation of Viscosity			5.07			2.79			1.77			0.89

cosity pulps obtainable from aspen[3] are a result of the low alkali charges used to delignify this species, rather than from any special attribute of its cellulose.

The viscosity-species relationship has so far been tested only at 170°C, but it seems likely that the viscosities of the pulps from various species will coincide at other pulping temperatures also. If this proves to be true, then the G-factor equation (previously tested only for spruce[2]) will have a wider applicability; a single relationship will cover a range of species as well as a range of alkaline processes[2].

It may also be possible to introduce a term for the effective alkali charge into the G-factor equation to produce a unified equation for the viscosity of unbleached pulp. Such an equation would be useful in process models for alkaline pulping. This work is now in progress.

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EXPERIMENTAL

Wood chips prepared from individual species were cooked separately in stainless steel bombs (2 L capacity) rotating in an oil bath. All cooks were done at constant pulping conditions: maximum cooking temperature was 170°C, the time to maximum cooking temperature was 90 minutes and the H-factor was 1550. Liquor-to-wood ratio for all cooks was 4:1 L/kg. The only variables were effective alkali charge and sulphidity and they are recorded in Table I.

The pulp viscosities were tested according to TAPPI Standard Method T-230 after delignification by acid chlorite bleaching at 25°C[4].

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