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Keywords
Chips
Anaerobic process
Handsheets
Biodegradation
Populus tremuloides
Storage
Density
Kraft pulps
Quality
Decay
Gas
Water

Abstract
Aspen wood chips were stored anaerobically for up to 26 months to determine effects of anaerobic storage upon hardwood pulp yields and handsheet qualities. Storage had no appreciable effect upon specific gravities of stored aspen chips or upon kraft pulp yields from these chips. Additionally, pulp handsheet properties were not significantly altered by anaerobic storage.

Effect of anaerobic storage upon quality of aspen pulpwood chips

Wallace E. Eslyn and James F. Laundrie

To determine whether anaerobic storage of wood chips would significantly reduce deterioration of the wood and possibly control losses during outside chip storage, the authors recently studied the effects on Douglas fir wood chips (1). Insignificant reductions in specific gravity and in kraft pulp yield occurred when these chips were stored either under water, or in an atmosphere of 95% nitrogen plus 5% carbon dioxide, for periods of up to 26 months. Additionally, properties of the pulp handsheets made from these chips remained essentially constant throughout the storage period.

But, would this information on Douglas fir chips be applicable to the more readily biodegradable hardwood chips? This uncertainty, coupled with the increasing use of hardwood wood chips in pulp and paper manufacture, led to the establishment of the present study. Its objective was to determine the extent to which deterioration occurred in a hardwood pulpwood during anaerobic storage.

Wallace E. Eslyn, Plant Pathologist and **James F. Laundrie,** Chemical Engineer, U.S. Department of Agriculture, Forest Service. Forest Products Laboratory, Madison, Wis. 53705. The Laboratory is maintained in cooperation with the University of Wisconsin.

Table I. Losses in Specific Gravity of Anaerobically Stored Aspen Wood Chips

Storage medium	*Storage time, months*	*Sp. gr.*	*Sp. gr. loss, %*
Water	0	0.369	...
	6	0.366	0.8
	12	0.362	1.9
	20	0.364	1.4
	26	0.359	2.7
Nitrogen plus carbon dioxide	0	0.369	...
	6	0.368	0.3
	12	0.366	0.8
	20	0.367	0.5
	26	0.366	0.8

RESULTS AND CONCLUSIONS

Specific gravity losses in aspen (*Populus tremuloides* Michx.) wood chips stored in an atmosphere of 95% nitrogen plus 5% carbon dioxide were insignificant, ranging from a low of 0.3% following 6 months' storage to a high of only 0.8% after 26 months' storage (Table I). As with Douglas-fir wood chips (1), higher specific gravity losses were experienced in water-stored aspen than in those stored in a gaseous atmosphere. At the end of 6 months these losses were 0.8%, while at 26 months they had risen to 2.7% (Table I). Specific gravity losses of aspen chips in both media were, contrary to expectations, lower than those experienced by Douglas fir chips stored under similar conditions. In any case, specific gravity losses of both woods were not above levels that could be expected to occur from natural leaching of water-soluble materials from the wood cells.

The effects of both types of anaerobic storage upon kraft pulping of aspen and upon its handsheet properties are provided in Table II. Each value shown in the table is an average of the results from duplicate pulpings and beater runs. Yields of kraft pulps remained the same throughout the 26-month storage period. With the exception of tearing resistance, which showed about a 10% loss, the properties of the pulp handsheets remained essentially constant. These results are similar to those obtained with Douglas-fir chips stored for the same period of time (1) and with aspen chips stored under 20-mil polyethylene film for a 185-day period (2).

METHODS

Fresh chips from 15 aspen logs were thoroughly mixed, and representative samples were extracted for moisture

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Table II. Effect of Anaerobic Storage Upon Kraft Pulping of Aspen and Physical Properties of the Pulps

Kraft pulping[a]						*Handsheet properties*[b]										
	Black liquor		*Yield*[c]			*Beating time, min at freeness of*		*Burst factor at freeness of*		*Tear actor at freeness of*		*Breaking length, km at freeness of*		*Density, g/cm², at freeness of*		
Storage time, months	*NaOH (Na_2O) g/liter*	*Na_2S (Na_2O) g/liter*	*Total, %*	*Screen-ings %*	*Kappa number*	*500*	*300*	*500*	*300*	*500*	*300*	*500*	*300*	*500*	*300*	*Bright-ness,%*
Storage under water																
0	2.5	6.9	55.4	0.5	11.2	17	38	59	73	71	66	10.4	12.0	0.75	0.81	41.5
6	2.4	6.6	55.2	0.1	10.3	15	32	59	71	68	60	10.6	11.5	0.76	0.82	42.0
12	1.8	7.1	55.9	0.2	12.4	16	35	60	73	69	62	10.5	11.6	0.75	0.81	38.3
20	2.7	6.6	53.9	0.4	11.6	17	37	62	75	76	68	10.9	12.1	0.76	0.82	40.8
26	3.2	5.3	53.9	0.3	15.3	12	26	57	72	60	58	10.4	11.7	0.75	0.81	36.4
Storage in N_2 + CO_2																
0	2.5	6.9	55.4	0.5	11.2	17	38	59	73	71	66	10.4	12.0	0.75	0.81	41.5
6	3.3	6.6	53.8	0.1	11.4	14	32	61	73	64	58	10.9	11.8	0.77	0.82	39.5
12	2.1	6.8	55.0	0.2	11.4	19	38	64	75	68	62	10.8	11.9	0.76	0.81	40.3
20	2.4	6.7	55.3	0.4	12.2	19	39	59	74	80	73	10.8	11.9	0.75	0.81	40.0
26	3.0	5.1	55.4	0.2	13.8	12	26	59	70	64	56	10.6	12.1	0.76	0.82	38.1

[a] Constant conditions used were 15% active alkali, 25% sulfidity, 4:1 liquor-to-wood ratios, 60 min from 100° to 170° C, and 75 min at 170°C. [b] Tested according to TAPPI methods. [c] Based on moisture-free weight of unstored chips.

content and specific gravity determinations (3) and for making duplicate kraft pulps. Average moisture content was about 98%.

First, 5000-g wet weight samples were placed into each of 24 5-gal glass bottles. To ensure the presence of adequate bacterial inoculum in the stored chips, 2 litres of Wisconsin River water and mud were obtained. This was mixed with distilled water to make up 9.6 litres, and then 400 ml of this mixture was added to each of the 24 bottles. Sufficient distilled water was then added to half of the bottles to completely cover the contained wood chips.

An anaerobic condition was created in the remaining bottles by drawing a vacuum of 20 in. of mercury for 1 hr, then replacing the withdrawn air with a mixture of 95% nitrogen and 5% carbon dioxide. Possible buildup of pressure due to evolvement of metabolic gases during storage was prevented by venting a tube into the rubber stopper at the top of the bottle and by inverting the bottle. Entry of oxygen into the bottle during incubation was circumvented by submerging the exterior end of the tube in water.

The bottles of chips were stored for periods of 6, 12, 20, or 26 months at 80°F under intermittent artificial light. At the end of each of the storage periods, six bottles—three of water-stored chips and three stored in a gaseous atmosphere—were removed. Contents of the two bottles of each type were removed for pulping tests, whereas those of the third bottle were used for determining specific gravity (3).

Duplicate kraft pulps were made at each sampling period under the following conditions: 15% active alkali; 25% sulfidity; 4:1 liquor-to-wood ratio; 60 min (100–170°C) and 75 min (170°C). Stainless steel digesters of 0.8 ft^3 capacity with heat exchangers and a liquor-circulating system were used for this small-scale pulping.

After the digester was charged with chips in a perforated basket, air was evacuated from the digester and the cooking liquor drawn in. At the end of the cook, the chips were partially washed inside the digester by running hot water (90°C) through them for 20 min. The partially washed chips were then removed and disintegrated with a stirrer in a stainless steel mixing tank containing hot water. After stirring for 10 min, the pulps were drained into a 100-mesh stainless steel screenbox, rewashed with hot water, and screened through a flat screen with 0.010-in. slots. The pulps were then partially dewatered in a 100-mesh stainless steel screenbox and transferred to a canvas bag in which the consistency was raised to about 30% in a hydraulic press. The pulp cakes were shredded, weighed, and sampled for consistency and Kappa number determinations.

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Received for review Oct. 11,1974.
Accepted Jan. 2,1975.