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Upgrading of recycled paper with oil palm fiber soda pulp

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Abstract

Recycled fibers, in comparison to its virgin counterpart, generally have reduced conformability and interfiber bonding capability due to irreversible hardening or hornification of these fibers. The extent and reversibility of the reduction is dependent on the original pulp type and on the papermaking process. Various methods are used to recover the lost potentials of the recycled pulp such as mechanical beating, use of chemical additives, physical fractionation and blending; the latter being the subject of this study using oil palm fiber virgin soda pulp as the upgrading strength material. With as little as 20% addition of virgin unbeaten pulp and considerably lesser amount of ca. 10% of beaten virgin pulp is sufficient to completely restore the strength of the recycled paper. The major mechanism of strength improvement is probably due to increase of interfiber bonding as a result of substitution of inactive secondary fibers with active virgin fibers.

Keywords: Upgrading; Recycled paper; Blending; Oil palm fiber; Virgin fibers; Soda pulp; Tensile index; Tear index

1. Introduction

In the processing of secondary fibers, the aim is to reclaim as much of the original papermaking potential as possible, which in turn is primarily affected by the pulping (Howard and Bichard, 1992; Wanrosli et al., 2001), refining (Laivins and Scallan, 1993) and drying (de Ruvo and Htun, 1981) processes. In general, the papermaking properties of the fibers deteriorate with extent of recycling. This behavior was attributed to the degradation in fiber bonding as demonstrated by Laivins and Scallan (1993). During a drying and rewetting cycle, the fibers lost their conformability and swelling capacity that is associated with the phenomenon of irreversible hardening or hornification of fibers as first introduced by Jayme (1944). It has been suggested that hornification occurred when the hydrogen bonds that were formed between cellulose chains in the cell wall during drying resist being broken during the rewetting process, resulting in only partial swelling since some chains remain bonded.

Although the effects of recycling on paper quality are known, a complete understanding of how to recover or minimize the loss of recyclability of secondary fibers is not known. Different methods are used such as mechanical beating and refining (Howard and Bichard, 1992), use of chemical additives (Gurnagul, 1995), physical fractionation (Gottsching et al., 1989), and blending (Szwarcsztajn and Przybysz, 1974). Each

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method has its own advantages and disadvantages. Blending of virgin pulp with recycled fibers is a physical upgrading treatment, which relies on the interaction between the two types of fibers. Mills occasionally use softwood fibers to impart additional strength to papers made from recycled paper. Malaysia being the largest oil palm producer generates massive amounts of lignocellulosic residues. It has been reported that during the recent past years, it has produced about 30 million tonnes annually of oil palm biomass, including trunks, fronds, and empty fruit bunches (Anon, 1997), which are rich in fibers, and has yet to be fully utilized. Hence, it is imperative that such fibers are to be exploited to the maximum. This paper attempts to investigate the potentials of these fibers as strengthening agents for upgrading the quality of recycled paper. The effect of beating is also discussed.

Our earlier study (Wan Rosli et al., 1998) on chemical pulping of empty fruit bunches (EFB) for pulp and papermaking, has shown that the alkaline process using sodium hydroxide alone appears to be the most interesting when its pulping efficacy and its environmental friendliness (in comparison with either sulphite or kraft processes) are taken into account. Based on such experiences, soda pulping has been adopted as the process and EFB as the starting material for pulp preparation.

2. Experimental

2.1. Materials

Oil palm pulp was prepared from fruit bunches of oil palm after being sterilized and stripped of their nuts. The resultant empty fruit bunches underwent mechanical treatment to loosen the fibrous strands, and were later washed, cleaned, sorted and dried.Recycled pulp from Malaysia old corrugated board (MOCC) was obtained from Pascorp Paper Berhad, Bentong, Pahang, Malaysia.

2.2. Pulping

All prehydrolysis cooks were carried out in a 4 l stationary stainless steel digester (without external circulation mixing) manufactured by NAC Autoclave Co. Ltd., Japan fitted with a computer-controlled thermocouple. The conditions employed were as follows: liquor to material ratio 8:1; time to maximum temperature −90 min; time at maximum temperature −120 min; maximum temperature −170 °C. At the completion of the cook, the pulps were mechanically disintegrated in a three-bladed mixer for 1 min at a pulp consistency of 2.0% and subsequently screened on a flat-plate screen with 0.15 mm slits, and stored in plastic bags for further use. The κ number of the resulting pulp is 20.

2.3. Handsheet making and blending

Both unbleached EFB and recycled pulps were reslushed by first soaking the semi dried pulp at room temperature for 24 h, followed by disintegration for 3000 revolutions in a standard laboratory British disintegrator. Handsheets of $65 \pm 2\,g/m^2$ were prepared using the Standard British Laboratory handsheet equipment. A series of blending experiments ranging from 0 to 100% virgin pulp at intervals of 10% were conducted. For beating trials, the EFB pulps were beaten in a Lampen mill for 1000 revolutions as described in Khairani (2000). Handsheet properties were evaluated following the TAPPI standard methods.

3. Results and discussion

The effects of blending on the major papermaking characteristics of various formulations are discussed in terms of wetness, sheet density, tensile and tear indices.

3.1. Effect on wetness

Wetness of pulps as measured by Schopper Riegler (°SR) increases with addition of EFB pulp for both unbeaten and beaten pulps (Fig. 1). The changes could be explained in terms of the intrinsic properties of the recycled fiber with respect to the virgin EFB pulp. Recycled fibers are fibers that have undergone multiple drying-rewetting cycles, during which they are stiffened or hornified. As a result, their swelling capacity is greatly reduced and water absorption is limited, hence the observed low wetness. Upon introduction of virgin fibers whose internal structure largely still remains intact, swelling could take place to the fullest,