Use of the Term "Bleaching" in the Context of Virgin and Secondary Fibers: A Clarification

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ABSTRACT
In its broadest sense, "bleaching" is defined as the removal of color. However, in papermaking and recycling, the term has more than one meaning, each associated with the treatments required to produce white pulps suitable for papermaking. In the context of virgin chemical fibers, bleaching has two functions: delignification and brightening. In bleaching virgin mechanical fibers, the primary interest is brightening. With regard to secondary fibers, bleaching can have three functions: color stripping of dyes (unique to recycling), delignification, and brightening.

KEYWORDS
Bleaching, Decoloration, Dyes, Reclaimed fibers, Recycling.

INTRODUCTION
The purpose of this article is to clarify terminology related to the bleaching of recycled (secondary) fibers. Recycled paper contains noncellulosic substances introduced during papermaking, conversion, or consumer use. Their removal or modification require specialized physical and chemical treatments not encountered in the production of bleached pulps from virgin fibers. These specialized treatments are divided into two categories: contaminant removal (including ink) and bleaching. In its broadest meaning, bleaching is defined as the removal of color. However, in papermaking and recycling, bleaching refers to three functions: delignification, color stripping (unique to recycling), and brightening. To clarify these functions, and why they specifically are included under bleaching, it is best to start by examining use of this term in the context of virgin fibers.

VIRGIN FIBERS
Unbleached virgin fiber furnishers are loosely divided into high-yield pulps, containing substantial amounts of lignin, and chemical pulps in which most of the lignin has been chemically removed. In either case, the pulps must be bleached if a white product is desired. This is where the first ambiguity in the term "bleaching" arises.

In high-yield pulps, native lignin, residual extractives, and other extraneous materials are retained during bleaching. Depending on the species of wood involved and the type of pulping process used, unbleached high-yield pulps may be relatively light in color. The bleaching stage, whether oxidative using alkaline hydrogen peroxide (HOOH) or reductive using sodium dithionite (Na₂S₂O₄, also called hydrosulfite), refers to a single function - elimination of chromophores present in lignin. During a single bleaching step, it is not uncommon to have brightness increase from an initial value in the high 50's to final values of up to 80% ISO brightness. Ideally, lignin and other materials are retained and bleaching refers simply to the removal of color.

In the context of chemical pulps such as kraft, bleaching has two functions. One is the removal of residual lignin left over from the pulping stage. The second is the removal of color. For example, in traditional bleaching using elemental chlorine (Cl₂, designated C), chlorine dioxide (ClO₂, designated D), and extraction with alkali (designated E), the sequence CEDED is used. In the first two stages, C and E, the lignin content might drop from 6% to 1.5% by weight. However, despite removal of 75% of the residual lignin, little brightening occurs. Brightness increases of less than 10% ISO, from perhaps 31 to 40%, are typical. In contrast,
during the next three stages (DED), a much smaller amount of lignin is removed. Meanwhile, the pulp is bleached to a final brightness of 87-90% ISO. Thus, in the context of chemical pulps, bleaching has two overlapping functions: delignification and brightening.

SECONDARY FIBERS

The goal of secondary fiber processing is to produce a clean, white pulp suitable for papermaking. As with virgin fibers, bleaching refers to chemical treatments that function to whiten the pulp. However, unlike virgin fibers, post-conversion and post-consumer papers contain a variety of added substances. These may consist of mineral fillers, starches, sizes, dyes, paper coatings, adhesives, toners, and inks. Fibers obtained from high-yield mechanical pulps may also have yellowed if exposed to light or heat (color-reversion). To obtain a clean white product, all these materials must be physically or chemically modified or removed.

Contaminants such as fillers, starches, sizes, and other materials added during conversion or consumer use are physically removed during pulping and washing steps. Many contaminants are physically removed in the pulping step, during which the fibers are separated and rehydrated. Other contaminants are removed in subsequent washing stages. Many of the components that give color to the paper, i.e., inks, toners, dyes, and color reversion products remain even after the pulping and washing stages. Of these, inks and toners are physically dispersed and removed in steps specifically designed for this purpose, while dyes, optical brighteners, and other colored substances are modified chemically. This distinction places inks and toners in the category of contaminant removal, making deinking distinct from bleaching.

The term bleaching is reserved for (1) color stripping, the chemical removal or modification of dyes, (2) delignification, and (3) brightening. Some ambiguity is inevitable because all three functions, color stripping, delignification, and brightening, may occur simultaneously. However, specific chemical treatments and reaction conditions employed, or in cases where no dyes are present, a separate brightening step may be necessary. The colored materials removed in this step are likely to include residual amounts of dye and optical brighteners, yellow color-reversion products, and small amounts of dispersed ink or toner particles.

In treating secondary fibers containing mechanical pulps, bleaching may begin as early as the pulping stage by the addition of alkaline hydrogen peroxide. Later, additional peroxide or sodium dithionite, oxidative and reductive color stripping and brightening agents that do not remove lignin are typically applied. Thiourea dioxide or formamidine sulfinic acid (FAS) is another reductive color stripping agent that shows promise for use with recovered fibers. For feedstocks consisting primarily of chemical pulp fibers, chlorine dioxide or sodium hypochlorite (NaOCl) are currently used for simultaneous color stripping, delignification, and brightening.

SUMMARY

In the context of virgin chemical fibers, bleaching may have two functions: delignification and brightening, while in virgin mechanical fibers, bleaching has the primary function of brightening. In recycling, bleaching includes color stripping, delignification, and brightening.

SUGGESTED READING

