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Review of Bleach Activators for Environmentally Efficient Bleaching of Textiles

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Abstract

Textile wet processing is the most polluting aspect of textile manufacturing and contributes to the global textile industry's substantial carbon footprint. Textile preparation of cotton typically includes scouring and bleaching at high temperature and high pH. Substantial amounts of wastewater are produced that must be treated prior to being released to receiving fresh water. Recent research in our laboratories has focused on the development and application of compounds that enhance the bleaching process. We have developed novel cationic bleach activators that can be used to bleach cellulosic fabrics and fiber blends at reduced temperature, pH, and time. Results show that after optimization equivalent or improved performance in whiteness, absorbency and strength are possible relative to conventional bleaching methods. One of the most promising bleach activators to date is N-[4-(Triethylammoniomethyl) Benzoyl]-Butyrolactam Chloride (TBBC). TBBC was designed in our group to a) exhibit strong oxidation potential when activated; b) have reasonable hydrolytic stability; and c) be inherently substantive towards cellulosic and other fibers. In this paper, we review the development of bleach activators for textile bleaching, and discuss the opportunities and potential hurdles involved in commercialization of bleach activators for textile wet processing.

Keywords: Bleaching; Bleach Activator; Hydrogen Peroxide; Cotton; Textile Processing

1 Introduction

Cotton cellulose is an ideal material for clothes, bedding and linens due to its high water absorbency, comfort and relative ease of dyeing and finishing. However, raw cotton contains natural colored impurities which significantly impair the inherent white appearance of cotton cellulose. Unless cotton is dyed deep or with dark shades, bleaching is required to remove the natural colored impurities prior to dyeing and finishing for the preparation of cotton textiles [1].

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Hydrogen peroxide is the most widely used bleaching agent in textile industry [2]. Rapid H_2O_2 bleaching is traditionally carried out under alkaline conditions (pH 10.5-12) at a temperature close to the boil, which results in high energy consumption and also gives rise to significant fiber damage. Additionally, it is essential to neutralize the bleach solution and rinse the fabric with copious amounts of water when the bleaching process is complete. Reduction of energy and water consumption in the textile industry is becoming increasingly important. Hence, the impetus to develop new and more eco-friendly systems for bleaching cotton and other fibers under benign conditions (low temperature, reduced pH, short treatment period, and low chemical concentration) is highly desirable.

A promising approach towards bleaching of cotton textiles involves so-called bleach activators in peroxide bleaching systems. Bleach activators are peracid precursors, which form peracids *in situ* by reacting with hydrogen peroxide in an aqueous solution (Fig. 1) [3, 4]. The generated peracids are more kinetically powerful bleaching species than hydrogen peroxide, which allow bleaching to be conducted under more benign conditions, such as under reduced temperatures. Bleach activators were originally developed for incorporation into domestic and industrial laundry detergents [5-8]. In recent years, they have been proposed for use in industrial textile bleaching in an attempt to overcome the drawbacks of traditional hydrogen peroxide bleaching [9-27]. While neutral (e.g. N, N, N', N'-tetra acetyl ethylene diamine, TAED) and anionic (e.g. nonanoyl benzene sulfonic acid, NOBS) bleach activators continue to be of interest, much of the recent research has focused on synthesis and application of Cationic Bleach Activators (CBAs).

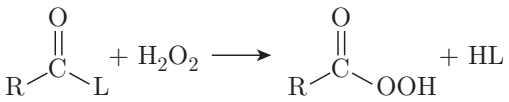

Fig. 1: Formation of peracids.

CBAs reported to date are based on a class of lactam-based peracid precursors (Fig. 2). They contain at least one cationic group, intended to provide water solubility and substantivity towards the negatively charged cellulosic substrates under aqueous conditions, and thus are very appropriate for bleaching of cellulosic textiles. In this paper, we review the development of CBAs for textile bleaching, and discuss the opportunities and potential hurdles to commercialization of CBAs for textile wet processing.

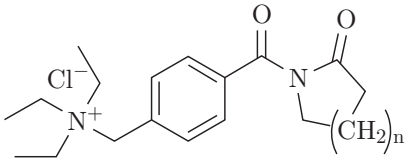

Fig. 2: Cationic bleach activators (where n=1-5).

2 Historical Development

CBAs were originally conceived and designed by the Procter and Gamble Company in the mid 1990s for incorporation into laundry and automatic dishwashing detergents [28, 29]. However,