An analysis of the water soluble components of Sappi Saiccor's effluent streams

F Ismail*, **DA Mulholland and JJ Marsh**
School of Chemistry, University of KwaZulu-Natal, Howard College Campus, Durban 4041, South Africa

Abstract

Sappi Saiccor is a pulp mill that produces high-grade chemical cellulose (dissolving pulp) from predominantly hardwood timber and is currently the world's largest manufacturer of this type of pulp. Attempts to isolate pure lignosulphonates were unsuccessful; however, an acid hydrolysis of the aqueous portion of the calcium effluent stream yielded a range of organic compounds. These included lignans, lignin-type precursors as well as small quantities of vanillin and syringaldehyde. The structures of these compounds were determined using NMR spectroscopic and mass spectrometric techniques.

Keywords: effluent, acid hydrolysis, lignan, lignosulphonates, dissolving pulp

Introduction

The Sappi Saiccor factory is situated at Umkomaas, 50 km south of Durban. It is the world's single largest manufacturer of chemical cellulose with the capacity to produce up to 560 000t of dissolving pulp per year (depending on grade mix), most of which is exported to Europe, America and Asia. It is also renowned for being the first company to produce high-grade chemical cellulose from the *Eucalyptus* tree (Thubron, 2002). Sappi Saiccor is one of the few pulp mills that produces chemical cellulose by the acid sulphite process, using both calcium (Ca) and magnesium (Mg) as bases. The wood chips are cooked in large digesters with liquor under high temperature (140°C) and pressure (10 bar). This process renders the lignin and hemicellulose in the wood soluble, so that it can then be washed out into the effluent streams. The four main streams of non-recovered effluent, that is, the calcium spent liquor, the magnesium pulp condensate and the two streams from the bleaching stages combine to form the main effluent stream before being pumped out to sea through a 7 km pipeline. Thus, the main effluent should contain a large proportion of lignins and lignosulphonates, as the main aim of the process is to produce a high-grade cellulose pulp free of lignin. Other components of the effluent would be hemicelluloses, resin acids, tannins and sugars.

In recent years environmental awareness has significantly increased and this has prompted Sappi Saiccor to discover ways of improving the quality of the mill's effluent before it is disposed of into the sea. At present, a large proportion of the calcium spent liquor effluent is pumped to an adjacent plant, where the crude lignosulphonates are recovered for commercial purposes (Thubron, 2002). In addition, the effluent from the magnesium pulp section is greatly reduced during the recovery process of the magnesium oxide base material. The only waste going to the effluent stream in this section is in the form of a condensate formed during the evaporation of the liquor. Saiccor's next step has been towards the characterisation of the effluent with the intention of identifying any commercially exploitable compounds, which can be extracted and marketed, thereby further reducing the impact of their industrial waste effluent on the environment.

The characterisation of pulping liquors has been carried out since the early 1950s. Studies have shown that the spent liquor from chemical pulping contains varying amounts of organic compounds from all wood constituents. The nature and concentrations of these compounds depend largely on the type of wood material used for pulp production, the type of pulping method employed and the composition of the cooking liquors (Sjöström and Alén, 1999).

There are two major chemical pulping processes, viz. sulphate pulping and sulphite pulping. Delignification during both sulphate and sulphite chemical pulping, using various types of bases, produces a complex mixture of products ranging from simple phenolic compounds to large macromolecules. These compounds form the major components of the total dissolved solids present in spent liquor effluents.

The importance of sulphite pulping has decreased during the recent decades, thus most of the information on the composition of sulphite spent liquors dates from the 1950s and 1960s (Sjöström and Alén, 1999). Early studies on the spent liquor of sulphite pulped aspen wood showed the presence of a large number of low-molecular mass aromatic compounds. These compounds were identified as vanillin, syringaldehyde, syringol, 4-hydroxybenzoic acid, dihydroconiferyl alcohol, syringaresinol and α-conidendrin (Pearl and Beyer, 1961; Pearl and Beyer, 1964a; Pearl and Beyer, 1964b).

Recent studies have concentrated on the isolation and characterisation of lignosulphonates from spent bisulphite liquor. A large number of sulphonated lignin-derived monomers and dimers have been isolated and identified using high-performance liquid chromatography (HPLC) (Bialski et al., 1986; Luthe, 1990). Examples of such compounds include 1-syringyl-2-propene-1-sulphonic acid, methyl-3,4-dimethoxybenzenesulphonate, 3-guiacylpropanal-3-sulphonic acid and 1,2-disulphonomethyl-1-(3',4'-dimethoxyphenyl)-propane (Bialski et al., 1986; Luthe, 1990).

Studies of the black liquor obtained from a *Eucalyptus globulus* bleached Kraft pulp mill showed the presence of many different types of compounds. The ether-soluble fractions were found to contain aromatic acids and phenolic compounds. The major components were identified as syringaldehyde, acetosyringone, syringol and syringaresinol (Neto et al., 1999). Other compounds

* To whom all correspondence should be addressed.
☎ +2731 2603090; fax: +2731 2603091; e-mail: ismailf4@ukzn.ac.za
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