Non-alkaline bleaching of wood pulp using pulsed RF dielectric heating: comparison with pulsed microwave enhanced bleaching

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Received 30 January 2001; accepted 23 April 2001

Abstract—Non-alkaline bleaching of thermo-mechanical pulps using 40 MHz RF dielectric capacitor heating is described. Experimental data obtained under RF irradiation are compared with non-alkaline bleaching under pulsed microwave at 2.45 GHz. Optimal processing time is determined. Effectiveness of non-alkaline bleaching of TMP in RF is shown to be close to that in microwave. Neither microwave nor RF irradiation, under non-alkaline bleaching conditions, is shown to result in detriment to the physical properties of the pulp.

INTRODUCTION
Recently, we have described the bleaching of mechanical wood pulps using hydrogen peroxide and solid magnesium or calcium carbonate under non-alkaline conditions [1]. Although initially the process was studied using conventional heating to temperatures of 70–100°C, it was subsequently shown that a pulsed microwave heating process could afford effective bleaching with brightness increases of 20–25 points for softwood pulps readily achievable [2]. This microwave processing had additional advantages in that the non-alkaline bleaching could be accomplished at high pulp consistencies (30–90%) and in very short processing times (<10 min, with total microwave irradiation times of ~90 s).

In dealing with microwave chemistry there are always questions regarding the efficiency of the process. Several factors may influence this efficiency, including the rapid rate of heating, the uniformity or selectivity of heating and thus effects on reaction rates, and the effects of the frequency of the electromagnetic field.

Currently, dielectric heating in RF electromagnetic fields is being widely used industrially for processes involving drying, melting, heating, etc. Continuous wave
power of several hundred kilowatts has been reached in industrial RF installations. In this article we describe further expansion of the pulsed low frequency processing of the pulp into the RF range. There are several advantages of using pulsed RF in industrial applications. These include the lower cost of RF energy, and that the scale-up from laboratory to industrial scale for reactors, as well as generators and ancillary monitoring equipment, is expected to be easier and cheaper for RF than for microwave equipment.

The particular chemical mechanism of non-alkaline peroxide bleaching of wood pulp is not completely understood yet; however, it is suggested that ions and free radicals play significant roles in this process [2–4]. Thus, dependence on the frequency of applied electromagnetic field cannot be excluded. This dependence can occur, for instance, from variations in the depth of penetration of the electromagnetic field into material with the frequency of electromagnetic field. The heating rate of the material may also be dependent on the frequency, as well as the non-uniformity of the temperature distribution across the volume of irradiated sample. Some specific frequency dependent interactions of the electromagnetic field with polar molecules, free radicals and ions can also play a definite role.

On the other hand, wood pulp contains a large amount of water. Therefore, if the frequency of the electromagnetic field lies in the absorption band of liquid water, that field can be used for heating up water containing pulp, thus providing necessary energy and temperature level for the process of bleaching. If there are no specific microwave-related issues and it is the high rate of heating-up of the pulp and uniformity of the heating that provides the effectiveness of the bleaching process, then RF irradiation should work as effectively as microwave when applied to the pulp.

In this paper we present experimental results of the non-alkaline bleaching of TMP with pulsed RF, using dielectric capacitor heating. The results are compared with data obtained from experiments in pulsed microwave.

**EXPERIMENTAL**

*RF apparatus*

The configuration of the 2.45 GHz Microwave installation used for the previous non-alkaline bleaching study of mechanical wood pulps has been described in the literature [1]. In this study, RF irradiation was generated with a RFC Macrowave Unit (Model 961) manufactured by Radio Frequency Co. Inc. This generator operates at frequency of 40 MHz and can provide 2.5 kW of power (CW mode).

A schematic diagram of the RF reactor setup for pulp bleaching is shown in Fig. 1. A pyrex tube (2) of inner diameter 30 mm was used as a reactor. The tube, filled with the prepared pulp mixture (1) was placed vertically inside the metallic applicator box of the RF unit (3), which played the role of ground electrode. The distance between the top and bottom metal plates was 18 cm. In order to prevent separation