Consultancy Report

Ash Pulping of Empty Palm Oil Fruit Bunches (Outputs 2 and 3)

FRP Project R6353

Prepared by Pira International, *March 2002*

Pira Ref: 01P12J0022

1 Background

In the mid-1990s, the Forestry Research Programme (FRP) of the United Kingdom Department for International Development (DFID), then managed by the Oxford Forestry Institute, commissioned from the Bio-Composites Centre in Bangor a project on innovative methods for pulping of empty fruit bunches from palm oil plantations in Malaysia and Indonesia to provide pulp for papermaking.

Although the Bio-Composites Centre in Bangor had difficulty in obtaining sufficient material from the counterpart organisations in Malaysia, an innovative technique of ash pulping was devised. On the basis of the laboratory studies, without scaling up to pilot or industrial scale operations, the Bio-Composites Centre took out a preliminary patent and was at one time engaged in discussions with palm oil processors and pulp manufacturers in Indonesia and Malaysia for licensing of this technology.

2 Project purpose

DFID wishes to have the technology either patented or the technology placed in the public domain through the open publication of the reports that currently remain unpublished. The current preference of DFID is for patenting and commercial licensing of the technology, with licence fees being returned to DFID itself to cover the costs of the centrally funded programmes on renewable natural resources research.

3 Research activities

The project was set out in three stages as described below.

3.1. Stage 1

3.1.1 Review the published and unpublished outputs and the correspondence file from FRP project R6353 "Utilisation of oil palm residues for the production of pulp and paper and fertiliser by-products in Malaysia", with respect to the work on empty fruit bunches. Work on oil palm stems and fibre bundles were abandoned during the project and should not be considered in this review. Work on fertilisers was never started.

3.1.2 By discussion with current staff at the Bio-Composites Centre (and previous relevant staff, if contactable), obtain any relevant information not on file or yet published.

3.1.3 Contact the relevant Malaysian organisations (at least the following: Forest Research Institute of Malaysia - FRIM, Palm Oil Research Institute of Malaysia - PORIM, Oil Palm Utilisation Committee of Malaysia, and the Agricultural University of Malaysia - UPM) to determine the differences between the technologies developed in Bangor and in Malaysia, and their relative technical and costs advantages.

3.1.4 Prepare a report to FRP on whether the technology/technologies developed through this project are sufficiently innovative and cost saving in relation to current technology used in Malaysia and Indonesia to be worth the expense of patenting.

3.2. Stage 2

If the first report from stage 1 is positive, prepare a second report to FRP on the additional laboratory or pilot-scale engineering work likely to be needed to secure a patent, the likely cost of such work, and the likely costs of securing a patent and of arranging commercial licensing subsequent to the granting of a patent.

3.3. Stage 3

3.3.1 If the first report from stage 1 is positive, contact the relevant commercial producers and processors of oil palm fruit bunches (plantation estates and mills, both trade associations and representative individuals) to determine the potential market for the technology if patented in the U.K. and/or South East Asia.

3.3.2 Prepare a report based on activity 1.6 on the potential market for the patented technology:

(a) How big is the market?

(b) What or who are the market elements (potential purchasers of licences)?

(c) How definite is their interest in this technology ?

The full project brief is attached as Appendix 1.

4 Stage 2

4.1. The Patent

The application made by the BioComposites Centre is attached as Appendix 2. As filed the parent is very simplistic and a considerable amount of work will be necessary. The original idea was to develop methods for using oil palm trunks or fibre bundles or ash. Residues from the pulping processes were to be tested as fertilisers put back onto oil palm plantations. The work was designed to identify an optimised pulping regime for EFB and other oil palm residues in order to produce fibre for the pulp and paper industry. It was recognised, however, that traditional pulping technology might only result in a relatively small consumption per annum. With this in mind, the use of EFB and palm oil ash were also investigated as a source for high volume pulping caustic. The results on the use of activated EFB as a source as potassium oxide (which may be converted readily to effective pulping liquor) prompted the patent application (application #: 9818064.9 file date: 20/8/98). Economies of scale are such that normal (Kraft) pulping of EFB is unlikely ever to be feasible in Malaysia. The BioComposites Centre attempted to optimise pulping regimes for EFB that were generally considered to be more environmentally considerate and economical on a smaller-scale. As described in the final report three basic pulping regimes were investigated; soda, potassium and ash. The effects of anthraquinone (AQ) as a pulping catalyst were also explored.

Potassium pulping was considered because it is more selective in the removal of lignin and thus promotes improved pulp properties. Potassium based black liquors can be further treated and employed as a basic fertiliser. This is not known to be feasible with sodium based pulping regimes. Prior to this study, ash pulping was identified only as means to produce Chemi-Thermo-Mechanical-Pulp, which requires low levels of causticity. Ash pulping cannot be used to produce EFB chemical pulp fibre at any scale, i.e. ash-liquor is not an effective pulping agent. However, initial experiments indicated that causticity could be improved. It was thought that this might promote a sufficiently caustic digestion medium. Ash liquor has the advantage that it is a natural source of potassium and hence can be further recycled and employed as fertiliser after initial use. A free source of potassium (potassium carbonate in traditional ash form) would potentially make small-scale EFB fibre production in Malaysia an economic possibility.

4.2. Interested Parties

As described in the first report the patent application has now lapsed and in order to determine whether to proceed with this patent, it is necessary to establish the degree of interest in the relevant industries. To this end contact has been made with research organisations in Malaysia and other possibly interested countries. The main research centres in Malaysia are:

Palm Oil Research Institute of Malaysia (PORIM)
P.O.Box 10620
50720 Kuala Lumpur   Contact: Ariffin Darus

Faculty of Agriculture
Universiti Putra Malaysia (UPM)
43400 UPM Serdang
Selangor DE

Contact: Prof. Mohd Yusof Hussain, Dean of the faculty of Agriculture

Forest Research Institute of Malaysia (FRIM)
Kepong
52109 Kuala Lumpur   Contact: Dr. Hoi Why Kong

At the time of the first report FRIM and PORIM expressed interest in co-operation, but there was no reply from the UPM to either e-mails or faxes to several persons. However, it was felt that the FRIM and PORIM probably best represent the interests of the palm oil industry.

Attempts have been made to re-open contact with the Malaysian

Institutes for the purposes of completion of stages 2 and 3, but to no avail. *Copies of the original patent application and requests for project proposals have been sent to FRIM and PORIM but no replies have been received.*

5 The Patent

At the time of the first report there was no response from the main plantations but positive response from the research institutes. This was felt to be encouraging, as these institutes can be very helpful with further patent work. In fact it is probable that the commercial units will not be too interested until patents have been franchised and they have something tangible to deal with. In view of the lack of interest of the institutes and the costs of the work as detailed in section 6 it is not recommended that work continue.

As stated, the patent application in appendix 2 is fairly brief and will need a lot of work to become a full patent. However the preliminary steps have been done to protect the concept i.e. the application and prior art in the form of published reports. Searches of published literature show other published work involving the pulping of empty fruit bunches but not by the same process for the same type of pulp. Therefore the patent is worth proceeding with. The presentations given by the BioComposites centre at various conferences constitute prior art.

In order to proceed with the patent, an agent will be needed, and it is assumed that the NRI or DFID will have their own. However a patent search using the internet has not shown up patents relating to this method of pulping, although there are enough patents on pulping of oil palms to show a healthy interest. With the permission of the Nri the outline has been sent to the interested Malaysian Institutes. Other information given will depend on the degree of co-operation needed to progress the patent.

There is no-one left at the Bio-Composite centre who has worked on the subject and therefore, as some of the work will probably have to be repeated, organisations will have to be found to do the work to “prove” the patent once a full application is to be made. As previously stated ,the Malaysian Institutes were interested and there is also interest in carrying out support work at the University of Stellenbosch in the Republic of South Africa.

6 Continuation of the Patent

In the process of the establishment of patent rights there will always be a significant amount of project work in order to answer objections to and prove the patent. The cost of such work will depend on the number of objections and the number of countries in which the process is to be patented.

6.1. Patent Costs

The cost of patenting varies by country but a typical cost for a US patent application (including legal fees and governmental fees) will be about £6000-£8000 plus renewal fees. In order to cover the process and protect the patent could cost over £100,000 in patent agent and legal fees.

On top of this will be the cost of practical work to defend the patent. On average the costs of such work are of the order of £2000 per day. The work will involve pilot plant pulping and laboratory testing to compare the patent process with others. From experience of other patent work there are likely to be at least 20 to 30 man days of work involved amounting to some £40,000 to £60,000.

The lack of interest and the total cost of the patent preclude any continuation.

Appendix 1

Consultant brief

TERMS OF REFERENCE FRP project ZF0145 (consultant number 1885)

A follow up to FRP project R6353, concentrating on ash pulping of empty fruit bunches from oil palms

Background

1. The Forestry Research Programme (FRP) of the then Overseas Development Administration (now Department for International Development/DFID) commissioned the BioComposites Centre in Bangor in July 1995 to develop improved methods for the use of residues from oil palm plantations. The original idea was to develop methods for using oil palm trunks or fibre bundles or ash. Residues from the pulping processes were to be tested as fertilisers put back onto oil palm plantations. Problems with the Malaysian collaborators reduced the studies to pulping of empty fruit bunches resulting from initial extraction of oil palm fruit. A preliminary economic analysis was conducted. Early expectations of rapid uptake of the laboratory technology by Malaysian and Indonesian oil palm mills and pulp mills were not sustained. A preliminary patent by the BioComposites Centre has lapsed.

2. FRP discussions with Malaysians at the 21st World Congress of the International Union of Forestry Research Organisations in Kuala Lumpur in August 2000 showed that at least some Malaysians felt that they had developed similar techniques in the 1980s and were waiting only for appropriate economic conditions to introduce them into industrial practice. A preliminary Malaysian patent may have been taken out in the late 1980s but has also lapsed.

3. Following indications from DFID's Environment Policy and Rural Livelihoods Departments, FRP wishes to know if a commercial market exists for the technology developed at Bangor, if that technology is made available through licensing of a new patent. If such a market does exist, a series of questions should be answered (see activity 1.6 below).

DFID wishes to have the technology patented and commercially licensed or, if patenting is unlikely to be successful or commercially able to cover the costs of patenting, the research reports placed in the public domain.

Activities and outputs

Phase 1

1.1 Review the published and unpublished outputs and the correspondence file from FRP project R6353 "Utilisation of oil palm residues for the production of pulp and paper and fertiliser by-products in Malaysia", with respect to the work on empty fruit bunches. Work on oil palm stems and fibre bundles was abandoned during the project and should not be considered in this review. Work on fertilisers was never started.

1.2 Through discussion with current staff at the BioComposites Centre (and previous relevant staff, if contactable), obtain any relevant information not on file or yet published.

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1.3 Contact the relevant Malaysian organisations (at least the following: Forest Research Institute of Malaysia - FRIM, Palm Oil Research Institute of Malaysia - PORIM, Oil Palm Utilisation Committee of Malaysia, and the Agricultural University of Malaysia (UPM) to determine the differences between the technologies developed in Bangor and in Malaysia, and their relative technical and costs advantages.

1.4 (output 1) Prepare a report to FRP on whether the technology/technologies developed through this project are sufficiently innovative and cost-saving in relation to current technology used in Malaysia and Indonesia to be worth the expense of patenting.

1.5 (output 2) If the first report (output 1) is positive, prepare a second report to FRP on the additional laboratory or pilot-scale engineering work (if any) likely to be needed to secure a patent, the likely cost of such work, and the likely costs of securing a patent and of arranging commercial licensing subsequent to the granting of a patent.

1.6 If the first report (output 1) is positive, contact the relevant commercial producers and processors of oil palm fruit bunches, plantation estates and mills, both trade associations and representative individuals) to determine the potential market for the technology if patented in the U.K. and/or South East Asia.

1.7 (output 3) Prepare a report based on activity 1.6 on the potential market for the patented technology:

(a) How big is the market?

(b) What or who are the market elements (potential purchasers of licences)?

(c) How definite is their interest in this technology?

Appendix 2

Preliminary Patent Application

Patent Application number 99211687.1

ABSTRACT

Improvements in or relating to the preparation of chemical pulp from cellulosic materials

This invention describes improvements in or relating to the preparation of chemical or semi-chemical pulp from cellulosic materials; more particularly it relates to a process in which an alkaline cooking liquor with a pH high enough to produce good quality chemical or semi-chemical pulp may be derived from vegetable plant residues.

Improvements in or relating to the preparation of chemical pulp from cellulosic materials

This invention relates to the preparation of chemical or semi-chemical pulp from cellulosic materials, more particularly it relates to a process in which alkaline cooking liquor derived from vegetable plant residues is used and may be discarded after use.

Palm trees such as the oil palm can provide both the source of the alkaline cooking liquor and the cellulosic material which is digested either wholly or partially by chemical means to provide a chemical or semi-chemical pulp for use in paper or board manufacture.

The oil palm is cultivated over a wide range of tropical climatic conditions and soil types, and a mature palm tree can produce five to ten bunches of 1000 to 2000 fruits. In order to extract oil from the fruits, they must be stripped from the bunches. This is generally done in a stripper, which is simply a rotating drum made of bars spaced apart so that the fruit can escape from the drum. As the drum rotates, the bunches are lifted up and then dropped so that the fruits are knocked off the bunches and are separated from the empty fruit bunches (EFB).

It is known that an alkaline cooking liquor can be formed by converting EFB into an ash, dispersing the ash in water to form an alkaline solution and then adding lime to causticise the carbonates present in the alkaline solution.

EFB ash contains carbonate as the primary anionic species giving an alkaline pH in solution. The main cation is potassium. Causticisation with lime has been necessary to produce a cooking liquor, which will produce a satisfactory chemical pulp.

We have now found we can by a simple process not requiring the addition of lime, produce from EFB a cooking liquor with a pH high enough to produce good quality chemical or semi-chemical pulp. A pH as high as about 14 can be achieved, making it feasible to use such a cooking liquor as a direct substitute for one formed directly from sodium or potassium hydroxide, or other commonly used pulping chemicals as used in any chemically assisted pulping processes such as kraft, soda, sulphite or chemithermo-mechanical pulping or cooking processes.

According to the invention, there is provided a process for the preparation of pulp by digesting cellulosic materials in a cooking liquor in which the cooking liquor is formed by the steps of:

(a) burning empty fruit bunches to convert them to an ash and ensuring that the ash when formed is heated to a temperature of at least 600°C so as to form a material which is substantially free of carbonates.

(b) adding the substantially carbonate free material to an aqueous medium. The heating of the ash to at least 600°C may be carried out during the initial burning process, or if the ash is produced by burning the EFB at lower temperatures it may be re-heated to form the substantially carbonate free material.

Our invention also includes a process where anthraquinones are added to the cooking liquor to increase the yield and/or the quality of the pulp by, for example, reducing the kappa number (residual lignin content).

Antraquinones which may be used include anthraquinone and alkyl anthraquinones such as methyl, ethyl, tertiary butyl and amyl anthraquinone.

The cooking liquor of the invention may be used in the digestion of EFB, trunk and fronds from palm trees. Other cellulosic materials which can be digested using the liquor include, but are not limited to, abaca, esparto, hemp, hardwoods and softwoods. Such digestion can be carried out at a temperature of about 1700^{o}C. and times in the range 120 minutes to 300 minutes.

Our invention also includes a pulp for use in paper or board making when made using an alkaline liquid prepared as disclosed herein.

Our invention also includes a process in which the cooking liquor of the invention is used in conjunction with known liquors, other novel liquors or pulp production processes.

The conversion of EFB and other vegetable residues from palm trees such as fronds to an ash is carried out by burning. Ash may be produced at the site where the fruits are separated from the bunches as the heat produced in burning the material may be used in processing the fruits e.g. in forming steam for use in the sterilisation of the fruits. The further heating of the ash to convert it to a substantially carbonate free material may be carried out at the same site or the ash may be transferred to a mill where the ash from more than one area may be combined for treatment.

The heating of the ash to a temperature of at least 600°C may be carried out in any furnace capable of achieving the temperatures needed. Such furnaces include regenerative furnaces in which heating is carried out by the direct action of a flame, electric furnaces, rotary kilns, fluidised bed boilers, smelter boilers and the like.

The time to achieve conversion of the ash to a substantially carbonate free state so as to yield a cooking liquor with a pH of at least 13.7, preferably about 14, will vary, as plant materials, whose composition can vary, are being used as a source of the ash. In the case of ash collected from different areas, not all the EFB may have burnt to the same extent and partially burnt material may be present in the ash. We have found that one convenient way to determine that the conversion process has been carried to a point where a liquor with a pH of at least 13.7 will be obtained from the ash is at a point where it takes on a green or blue tinge.

In any pulping process, the alkaline cooking liquor is converted during the digestion process into a so-called black liquor. This material must be treated before it can be disposed of, as it has high chemical and biological oxygen demand. It is usual to recover the alkali content where additional lime is added, and to burn any organic materials. Such recovery is unnecessary in the case of the black liquor produced from a pulping process using the cooking liquor of the present invention, as no chemicals have been added which need to be recovered in order to achieve an economically viable pulping process. If the pulping mill is close to the plantations, the black liquor can be used as fertiliser or treated with acidic materials to precipitate a substantial proportion of the soluble solids present in the liquid and produce a liquid which when separated from the precipitated solids has an acceptable Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD), so that it can be disposed of without harming the environment.

Our invention will be further described by reference to the following examples which illustrate but do not limit the invention.

In all of the following examples 39kg of EFB were burnt in a furnace resulting in approximately 2.38kg of ash, which was collected from the ash tray of the furnace and transferred to a muffle furnace where it was heated to 600°C for ten hours by which time all of the ash had developed a distinct green/blue tinge.

Example I

1.975kg of the green/blue ash was added to 7 litres of water at 80°C and was stirred at this temperature for 5 hours. After filtering off solids, 5 litres of liquor were obtained with a pH of 13.9.0.1 % by weight of anthraquinone was added to the liquor. This liquor was used to digest 500g (oven dry mass) of EFB. This was carried out by heating the EFB/liquor mixture to 170°C, and holding the mixture at that temperature for four hours. Satisfactory pulping was achieved, as shown by the following results of testing the pulp obtained. The screened fibre yield was 39.42% with a Kappa value of 10.1. Canadian Standard Freeness was 250, and the tensile index (after 20 min. valley beat) was 44.5 Nm.g-I. The alkali consumed was 67.9 %.

Example 2

This example is a repeat of example one, using the same quantities but without the addition of anthraquinone. 1.975kg of the green/blue ash was added to 7 litres of water at 80°C and was stirred at this temperature for 5 hours. After filtering off solids, 5 litres of liquor were obtained with a pH of 13.9. This liquor was used to digest 500g (oven dry mass) of EFB. This was carried out by heating the EFB/liquor mixture to 170°C, and holding the mixture at that temperature for four hours. Satisfactory pulping was achieved, as shown by the following results of testing the pulp obtained. The screened fibre yield was 39.72% with a Kappa value of 11.1. Canadian Standard Freeness was 199, and the tensile index (after 20 mm. valley beat) was 49.9 Nm.g-1. The alkali consumed was 66.4%.

Example 3

1.870kg of the green/blue ash was added to 7 litres of water at 80°C and was stirred at this temperature for 5 hours. After filtering off solids, 5 litres of liquor were obtained, with a pH of 13.7. 0.1 % by weight of anthraquinone was added to the liquor. This liquor was used to digest 500g (oven dry mass) of EFB. This was carried out by heating the EFB/liquor mixture to 170°C, and holding the mixture at that temperature for four hours. Satisfactory pulping was achieved, as shown by the following results of testing the pulp obtained. The screened fibre yield was

37.05% with a Kappa value of 16.6. Canadian Standard Freeness was 220, and the tensile index (after 20 mm. valley beat) was 46.3 Nm.g-1. The alkali consumed was 69.5%.

Example 4

This example is a repeat of example three, using the same quantities but without the addition of anthraquinone. 1.870kg of the green/blue ash added to 7 litres of water at 80°C and was stirred at this temperature for 5 hours. After filtering off solids, 5 litres of liquor were obtained with a pH of 13.7. This liquor was used to digest 500g (oven dry mass) of EFB. This was carried out by heating the EFB/liquor mixture to 170°C, and holding the mixture at that temperature for four hours. Satisfactory pulping was achieved as shown by the following results of testing the pulp obtained. The screened fibre yield was 40.21% with a Kappa value of 19.2. Canadian Standard Freeness was 204, and the tensile index (after 20 min. valley beat) was 51.5 Nm.g-1. The alkali consumed was 67.45%.