INTEGRATED PROCESSING OF OIL MALLEE TREES FOR ACTIVATED CARBON, EUCALYPTUS OIL AND RENEWABLE ENERGY

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1. SUMMARY

The rate of planting of mallee eucalypts can be greatly enhanced when commercial applications are found for the trees. Production of eucalyptus oil provides a good use for the leaves but can not utilise the wood. This paper summarises an exciting application for the wood to make activated carbon and electricity.

CSIRO Forestry and Forest Products has developed technology for the production of charcoal and activated carbon from wood and wood wastes. This technology, which is licensed to Enecon Pty Ltd, involves:
- controlled carbonisation of wood to produce charcoal
- further processing of that charcoal to make a variety of activated carbons.

The production of charcoal and activated carbon also releases energy that is suitable for production of steam or electricity generation. The CSIRO process is believed to be the only technology available in the world that integrates this energy generation with the manufacture of carbon products.

Charcoal has large Australian and international markets as a cooking fuel and in metallurgical processes. It is also a major feedstock for the production of activated carbon, a powerful adsorbent used in many industries, including water treatment, food production and gold recovery. The annual world market for activated carbon is estimated at more than A$ 1 billion.

Importantly, this carbon and energy production can occur in parallel with production of eucalyptus oil. Thus all of the costs of tree growing, and many of the costs of building and operating centralised processing plants, can be spread over multiple products. This integrated approach has the potential to offer significant improvements to the commercial viability of oil mallees.

2. INTRODUCTION

Perennial crop planting has been identified as an important mechanism for reducing salinisation in much of Western Australia. Mallee eucalypts have been identified as an important tree in this regard, particularly for low rainfall zones.

Much of the focus on the use of oil mallees for land care has been based on a realisation that the development of commercial returns from mallee trees will greatly increase the extent to which it can and will be grown by farmers. With greater planting, increased landcare benefits will follow. Much work has been done on developing understanding and techniques for efficient recovery of eucalyptus oil from mallee leaves, together with markets for this oil. However production of oil alone means that there is no return from the mallee wood, which comprises half of the biomass being grown. If this wood can be used commercially there will be an increased likelihood of a commercially viable industry.

This situation has prompted the concept of Integrated Tree Processing (ITP), where the whole tree is processed and the costs of growing, harvesting, transport and processing are spread across a greater number of products than before. Of the products that can be made from mallee wood, this work has focused on carbon products and energy.

3. DEVELOPMENT OF THE TECHNOLOGY

Activated carbon is a powerful adsorbent or "sponge". It is used extensively around the world in many ways, including the cleaning of potable and waste water, gas cleaning, food manufacture and gold recovery. The technology for manufacture of activated carbon from wood that is discussed in this paper has been developed by CSIRO Forestry and Forest Products CSIRO over a number of years.

In the 1970s CSIRO assisted saw @Hs with waste disposal by improving incinerator efficiencies. This work led to the investigation of available technologies for waste wood combustion and also of methods for carbonisation to produce charcoal and convert wood wastes into commercially viable products.

The fluidised bed carbonisation of wood wastes was first investigated by CSIRO at the laboratory scale for sawdust and then in a pilot scale plant capable of carbonising 0.25 tonne/hour of green wood chip feed. Hardwoods and softwoods have both been tested successfully.

The fluidised bed system developed for charcoal production is quite versatile. It can bum green wood. It can bum wood of varying sizes (eg. chips and sawdust). It can be controlled to allow partial combustion for charcoal production or complete combustion for maximum energy recovery.

The charcoal produced by this process has a potentially large markets in Australia and overseas for cooking and metallurgical uses. It can also be used as a feedstock for the production of activated carbon. CSIRO's interest in activated carbon developed from the fact that all activated carbon used in Australia for gold recovery is imported. Activated carbon produced from timber does not normally have the required hardness levels required by the gold industry, so CSIRO developed technology to process the charcoal prior to activation and increase the hardness achieved. Initial samples of carbon made from jarrah have been tested *in situ* at the Ora Banda gold mine in Western Australia and found to perform as well as one of the best commercial carbons used in the industry.

The carbons produced by the CSIRO process also have potential applications in the water treatment, food and chemicals industries, where timber-based carbons from other countries are already used. As part of the study work programmed for 1999, Enecon will commission independent testing of carbons made by the CSIRO process for a range of water treatment applications relevant in local and overseas markets.

Enecon Pty Ltd is an Australian engineering company tat carries out consulting work and technology development. Enecon holds an exclusive licence from CSIRO for the commercialisation of this technology, and is working towards this goal by assisting interested groups to analyse feeds, products and commercial opportunities via test work and feasibility studies. Enecon assists with such work and is also developing links to product markets in Australia and overseas,

4. DESCRIPTION OF THE TECHNOLOGY

4.1 Process

The CSIRO technology comprises two main parts:

1. The first part is a Fluidised Bed Combustion (FBC) system that allows controlled combustion of the residues.

    - Complete combustion favours the production of heat energy, which can be used on site for thermal energy or as a starting point for steam and power generation.

    - Partial combustion releases less energy as heat but provides charcoal as a product that is suitable for sale as a fuel, a reluctant for the metallurgical industry, or as a feed to a carbon activation plant.

2. The second part of the CSIRO technology is a process that produces activated carbon (AC) in a variety of forms suitable for use in the gold and water treatment industries as well as other applications.

The FBC plant can operate on a stand alone basis to produce energy, however the major feed material for the AC plant is charcoal from a suitably configured FBC plant. The activated carbon plant produces a much higher value product than the FBC plant so, although it cannot operate in its own right, it has the potential to improve the commercial viability of a complete system.

4.2 Products

The two systems could provide a range of products with commercial value:

1. The FBC plant produces heat from wood combustion. This heat could be used for timber drying via a hot oil system as with other types of waste burning plant, or for the generation of steam or electricity.

2. The FBC plant in partial combustion mode produces charcoal which could be suitable for sale as a fuel or to the galvanising and metallurgical industries. Australian production would be used locally for specific opportunities or exported to large, existing markets in Asia, USA or Europe.

3. The AC plant produces activated carbon. Activated carbons are used in industrial separation processes because of their ability to preferentially adsorb particular chemicals when introduced to solutions containing those chemicals. The nature of each activated carbon and its industrial application dictates the production steps required to optimise particular adsorptive and mechanical qualities.

4. The AC plant also produces significant quantities of energy. Whereas in the FBC plant energy is recovered via heat transfer, in the AC plant energy is recovered via the production of water gas during the activation step. Water gas is a mixture of CO and H2 and is both higher in energy value and cleaner than the "wood" gas produced by gasification processes. This gas can be burnt to generate heat for a variety of process uses, including cogeneration of steam and power.

5. MARKETS AND PRICES

Raw Materials

Activated carbon is manufactured from a variety of feedstocks - principally wood, coal, peat and coconut shell. The characteristics of the feed material influence the physical and adsorptive properties of the activated carbons, however the processing steps used also influence product characteristics. CSIRO carbon from wood can therefore be compared against carbons from other feedstocks because the particular processing steps in the CSIRO process can impart characteristics not normally found in wood-based carbons.

World Market

A world market review for activated carbon in 1998 (BM Coope & Partners) has estimated a total world market of some 700,000 tonnes. Market growth over the period 1988-1998 was estimated by Coope at 4-6% per year. The majority of production in the USA and Europe is by six or seven manufacturers in each region, with two companies, Calgon and Norit, being the largest producers.

Activated carbon has a great variety of uses, including:

Liquid Phase	**Gas Phase**
* potable water	* solvent recovery
* wastewater	* petrol recovery
9 sweetener decolourisation	* industrial offgas control
* chemical processing	* catalysis
* food, beverages, oils	
* pharmaceuticals	
* mining	
* groundwater	
* household uses	

Australian Market

The market for activated carbon in Australia is approximately 7,500 tonne/year, which is made up of a mixture of imports (approx. 5,000 tonne) and local production. The mix of uses differs from the figures for USA provided above, with approximately two thirds of Australian consumption occurring in the Carbon-in-Pulp (CIP) process for gold recovery. This process is used for almost all gold recovery in Australia.

Selling Prices

Prices for activated carbon (AC) range from $1,000/tonne for low grade powders through to $12,000 or more for high grade carbons with additives and specialised attributes. Typical prices include:

* as low as $1,000/tonne for low grade AC supplied from China and used for some water treatment applications

* $1,200 to $1,750/tonne for coal-based AC produced in Australia for general water industry and decolourisation applications

* $2,500 to as much as $4,500/tonne for AC for gold industry use

* $3,500 to $7,000/tonne for specialised powdered AC used for short term odour and taste removal from potable water.

Production and Trade

Activated carbon production occurs around the world. In the case of coconut shell based carbons, preliminary processing in Asia is often followed by further processing in Europe.

The import and export of AC to and from Australia provides a good indication of the fluidity of activated carbon trade. Australia currently imports two thirds of its AC while simultaneously exporting approximately half of its domestic production. This is because Australia does not currently produce commercially an AC suitable for the gold industry, but does produce AC that is recognised internationally for water treatment and decolourisation abilities. Activated carbon marketing in Australia and elsewhere is carried out by producers and also by trading houses or agents. Australian AC is currently sold through international carbon traders into Europe, Asia and South Africa. Both current Australian producers make AC from coal and both consider export as their viable growth market.

6. TYPICAL PLANT COSTS AND RETURNS

A full scale integrated processing plant can be designed to a range of sizes. It may be built in phases, with an initial plant being expanded over several years according to availability of feed and product markets.

For the purpose of showing the commercial viability of this approach, a full scale plant with a capacity of 100,000 tonnes per year of feed as whole trees is considered. The initial estimates for this plant indicate the following attributes:

Feed material (equal amounts of green wood and leaf)	100,000 tonne/year
Eucalyptus oil produced	2,000 tonne/year
Activated carbon produced as pellets	5,000 tonne/year
Renewable electricity produced	5 MW
Plant capital cost	approx. A$20 million

A plant of this size, with product sold largely as export at prices understood to be achievable for oil and carbon, plus electricity sold into the WA grid, shows an attractive internal rate of return. More accurate costing is under development via the study work described below.

The world markets for eucalyptus oil and activated carbon are considerable and it is intended that, as these markets are developed, a number of full scale plants will be built across the wheat belt. Such an undertaking represents many years of profitable work for the industry, always driven by commercial returns with the attendant land care benefits.

Importantly, most of the plant can be built in Western Australia, the exceptions being items that are not manufactured locally, such as stern turbines.

Operation of a plant such as this offers significant employment for rural communities. The plant operates 24 hours per day and shift personnel plus management, administration and maintenance personnel may total 20 for each plant. Additional jobs will come from planting, harvesting and transporting the trees.

7. PROJECT DEVELOPMENT

A comprehensive feasibility study is already underway to investigate the potential for integrated processing of oil mallee trees to make eucalyptus oil, activated carbon and renewable energy.

The study includes the following activities:

a) Cost analysis of feed prices, delivered as whole tree to a central processing plant.

b) Laboratory work by CSIRO to manufacture, test and optimise granular and pelletised activated carbons.

c) Independent test and comparison work on these carbons by two Cooperative Research Centres.

d) Study work by Enecon to develop material and energy balances, equipment list and capital and operating costs for a full scale plant.

e) Study cash flows to confirm the project's economic viability.

This study and other work should allow us to carefully and logically develop the integrated processing concept to the stage where the first of several full scale plants is built.

