

SKEPTIKAL CHYMIST

At present the major sources of many highly useful and valuable organic compounds, ranging from plastics to medicines, are non-renewable hydrocarbons—oil and coal. This article looks at the possibility of obtaining these chemicals on a small scale from *renewable* sources—such as wood and seaweed.

On examination of the present and past processes for the production of chemicals from renewable natural resources, the following significant points emerge:

- ◆ Many of the resources are renewed in a fairly short life-span (1-10 years).
- ◆ They are often labour, as opposed to capital intensive.
- ◆ Many processes use only 'waste' by-products of normal production.
- ◆ Many of the processes are based on pre-industrial techniques; and are thus readily adaptable to the criteria of *Alternative Technology*.

Products to which these criteria apply include:

Plant Products: wood, sugar, starch, natural dyes, insecticides, oils, fats, waxes, cosmetics, cork, drugs, pectins and peat. *Marine Products:* seaweed and drugs. *Animal Products:* drugs, enzymes, gelatin, glue, dairy products (rennet etc).

Space (and personal ignorance) will not permit me to discuss all of these processes. I have therefore chosen three. The first is as yet theoretical, but should become of increasing importance, namely the extraction of *organic chemicals from carbohydrates*. And two others of proven use: *wood* and *seaweed*.

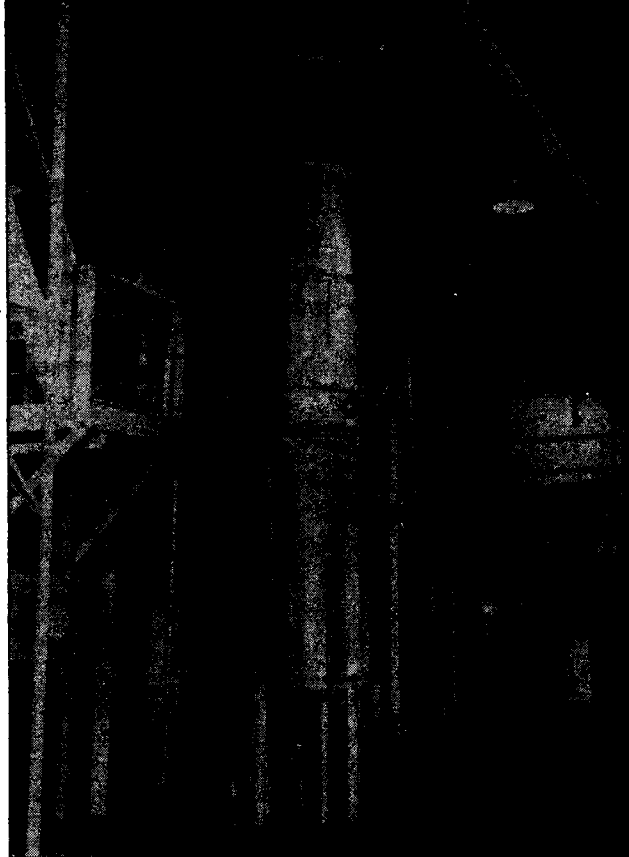
ORGANIC CHEMICALS FROM CARBOHYDRATES

Organic chemicals are very important to humanity today. They supply the starting materials for: plastics, perfumes, drugs, colouring dyes, petrol and other solvents; fats and waxes, and a host of other everyday substances. At the moment the major sources for most of these organic 'building blocks' are petroleum and to a lesser extent coal—both non-renewable.

Up to twenty years ago a significant quantity of chemicals such as ethanol (the alcohol in booze), propanol, acetone and butanol were produced from carbohydrates such as starches, sugars and molasses, but the wide availability of cheap petroleum in the middle 1950's rapidly killed off this more ecologically sound process.

The greatest natural source of energy is the Sun. Plants trap and store the Sun's energy in the form of carbon compounds. These compound carbohydrates are formed from carbon dioxide, water, and trace elements, in a reaction sustained by light and catalysed by chlorophyll, the total reaction being called *photosynthesis*. These carbohydrates occur in a variety of forms (See table below).

Although, in theory, any of the above sources may be utilised, the most promising candidate



A modern still for the distillation of turpentine from Oleoresin developed by the US Naval Stores Station, Olustie, Florida.

would appear to be cellulose, and to a lesser extent starch. Cellulose is the world's major industrial carbohydrate, annual world production being in the region of 100 billion tons (American). Cellulose itself is a rather intractable polymer of glucose units, and the hydrolysis of this polymer (enzymatically or chemically) to glucose would appear to be a necessary step in most schemes making use of it.

The reactions of glucose, of interest to anyone hoping to use it as a starting material for synthesising the organic building blocks which currently come almost exclusively from petroleum, are widely scattered in the chemical and biological literature and require digging out by someone! Until this is done it is impossible to sketch out

Carbohydrates	Sources
Cellulose	Trees, shrubs, plant stalks, grasses, and so on, bacteria.
Starch	Cereals, roots, tubers, pith
Glucose	Starch, honey, grapes, dates
Sugar (Sucrose)	Cane and beet, maple tree
Gums, pectins and mucillages	Trees, fruit of all kinds, seeds
Hemicelluloses and pentosans	Trees, Leafstalk, corn-cobs
Alginates, agars and carrageenans	Sea weeds
Copra and nuts	Coco-nuts, trees
Honey	Bees
Microbial polysaccharides	Bacteria and moulds
Specialist sugars	Fermentation industries, polysaccharides
Biologically active carbohydrates	Animal tissues and fluids, micro-organisms, synthetic compounds

From 'Industrial Uses of Carbohydrates', Maurice Stacey *Chemistry and Industry* pp. 222-226 (1973).

realistic schemes of relatively straightforward syntheses suitable for those who do not have the resources (money and technicians), or desire, to slave away at some complex route. Reactions, such as the aromatisation of glucose to catechol (1, 2-Dihydroxybenzene) are well known and may provide some starting points, (ironically, catechol is one of the few organics readily available from natural resources).

But the most direct way of producing some chemicals may be by reviving some of the earlier fermentation techniques. Ch. Weizmann, the first President of Israel, did pioneering work in this area, and a recent (1974) report from the US National Academy of Sciences suggests that the Americans may also be taking it seriously.

WOOD

Until the middle and late 19th century, when the distillation of coal assumed prominence, the distillation of wood supplied many of the common organic chemicals (especially solvents). As Fig 1 indicates, wood could supply a very wide range of organic chemicals.

Rather than go into further detail on all these processes some of which are fairly complex, I shall

select one which illustrates the potential of wood chemistry and which, due to its long tradition, may be of immediate use, namely: wood distillation.

For many thousands of years wood has been used as a fuel and as a source of charcoal for the reduction of ores for their metal content. However, it was not until the beginning of the era of modern chemistry that the real usefulness of all the by-products came to be recognised. By the end of the 17th century it was known that wood burnt in closed vessels produced vapour from which could be condensed a tar and a watery liquid, termed pyroligneous acid. In 1658 Glauber identified the main product of this distillation as acetic acid (vinegar), and Boyle, in his *Sceptical Chemist* (1661), noted the presence of an inflammable volatile liquid, 'wood spirit', later named methyl alcohol, signifying the wine of wood. However, it was not until the Frenchman Lebon, in 1799, took out a patent for, "a new method of employing fuel more efficiently, for heating or lighting, and of collecting the various products" (soon all Paris was to admire his gas-lamp in the Hotel Seignelay), that things really got going.

The basic details of the process are given in Fig 2.

Fig 3 shows the section of a battery of retorts (A) of the Mathieu type. The wood is charged automatically from the running buckets, (c), suspended at g. At the end of the operation the charcoal is discharged into the vessel, (P), which is provided with a cover to prevent the hot charcoal from igniting in the air. The vapours from the distillation pass into the tube, (H); which conducts them into a coil cooled by the water in T and then into the barrel, (J), where the tar and the pyroligneous acid separate; the gas, which does not condense, but is still partly combustible, is washed and passes through the pipe, (k), to be burnt under the furnace-hearth, (D); there is no danger of explosion, since, if there is any air in the retorts, it cannot communicate with the hearth, the barrel, (J), serving as a water-seal.

The products obtainable from a typical dry distillation operation are as shown in Fig 4. See overleaf.

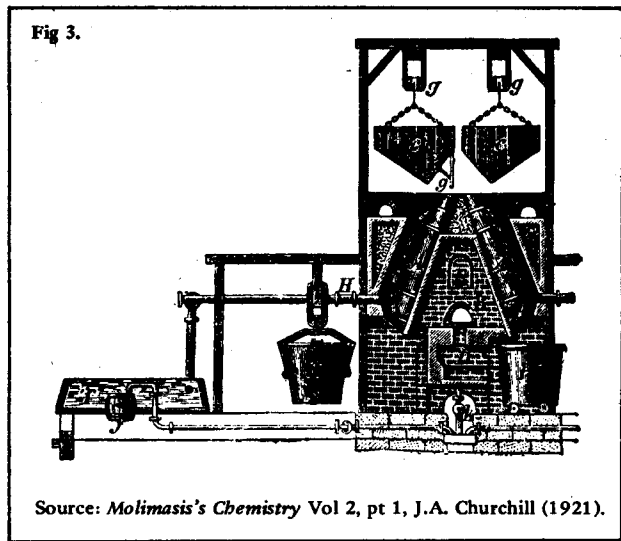
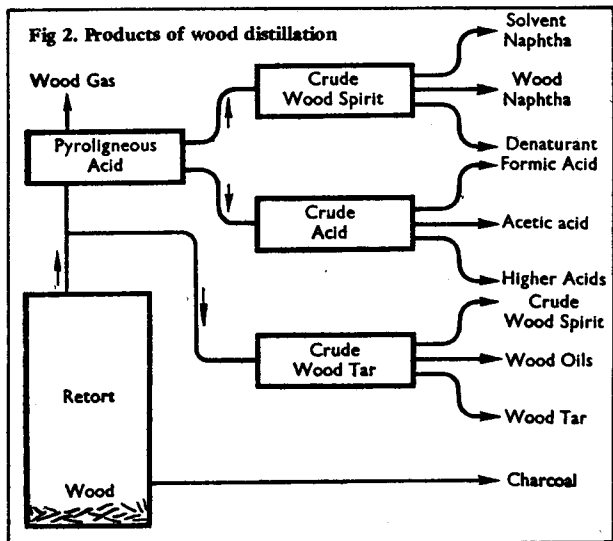
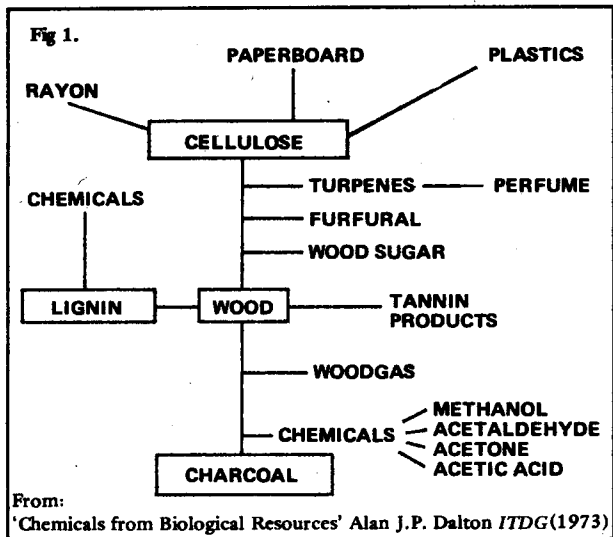


Fig 4.
Products obtained by dry-distillation of 1 ton of hardwood scrap (ca. 70% maple, 25% birch, 5% ash, elm and oak)

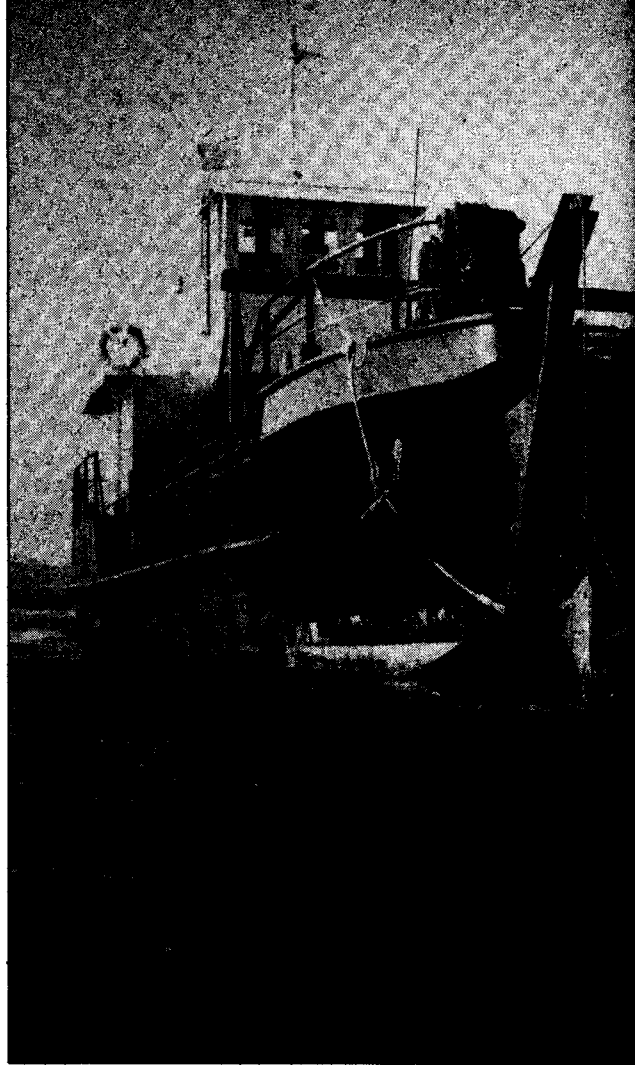
Charcoal	600 lb
Gases:	5,000 cu ft
Carbon dioxide (38%)	
Carbon monoxide (23%)	
Methane (17%)	
Nitrogen (16%)	
Methanol	3 gall
Ethyl acetate	15 gall
Ethyl formate	1.3 gall
Acetone	0.7 gall
Creosote oil	3.3 gall
Sol. tar	22 gall
Pitch	66 lb

Source: Alan J.P. Dalton, 'Chemicals from Biological Resources' ITDG, (1973).

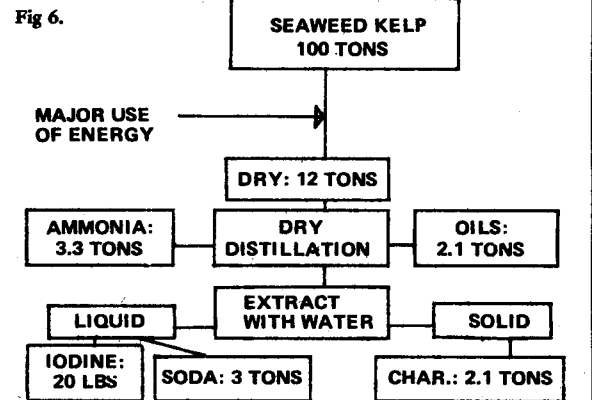
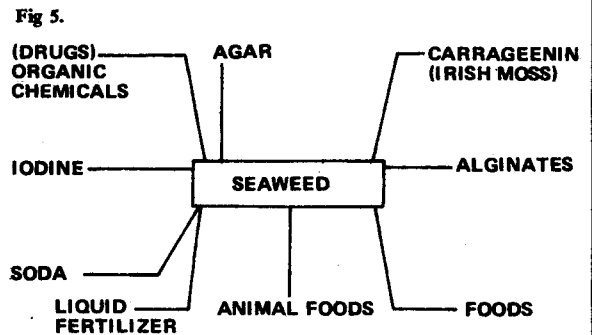
SEAWEED

From the 17th century until the development of the Le Blanc process, in 1781, seaweeds formed the major source of alkali (sodium and potassium carbonates) in Europe, their ash being known in Scotland and Ireland as 'kelp'. From then until the 1930's there was a lull in the industry, but from then on increasing use was found for one of the major products: Alginic acid. Figs 5-8 give some idea of the products available from seaweed; the earlier manufacture of soda and iodine; the three major products of the industry; the organic chemicals (sugars and steroids) that have been produced by simple laboratory procedures; and the occurrence of seaweeds throughout the world.

The giant kelp *Macrocystis pyrifera*



Harvesting seaweed off the coast of Australia



From: 'Chemicals from Biological Resources' Alan J.P. Dalton ITDG (1973)



Fig 7.

Chemicals potentially available per annum from 1,000 tons of fresh 'L. Cloustoni' (whole plant)

Chemical	Calculated tonnage present in weed		
	May	October	Average
Alginic acid	28	31	30
Mannitol	10	33	18
Laminarin	Nil	40	14
Fucoidin	6	9	7.5

Source: *Organic Chemistry Today* F.W. Gibb, Penguin (1964).

Fig 8.

Product	Uses
Agar	Microbiology Foodstuffs Pharmaceuticals
Alginates	Pharmaceuticals Foods Rubber Textiles Paper
Carrageenin	Largely foodstuffs Ceramics Alcoholic drinks Electroplating Leather finishing

Source:
Alan J.P. Dalton,
'Chemicals from
Biological Resources'
ITDG, (1973).

It would appear that much Scottish and Irish seaweed is still gathered by hand—which cannot be much fun on a rainswept and windy beach at the height of winter. The processes for the extraction of these chemicals have been developed by the now defunct Scottish Seaweed Research Institute, during the 1950's, and may well have been improved on by now. The original methods were simple and admirably suited for communities located near large amounts of seaweed; for most practical purposes the North West coast of Scotland and the West coast of Ireland.

Incidentally, it is possible to cultivate seaweed (the red seaweed, *Porphyra tenera*, has been cultivated for food in Japan for years), but the problem of interference to shipping and fishing, coupled with the major changes in the environment which would occur as a result, led to the dropping of such proposals from the British industry, under pressure from the Ministry. Anyone familiar with the apparently uncontrollable growth of red seaweed now going on along Britain's south coast, will understand the need for caution. In short, the problems may well be social and ecological rather than technical.

Alan Dalton

Part of an alginate producing plant in Scotland

