CONIFER TREES, PINE CHEMICALS, AND THE SEEDS OF A NEW CHEMISTRY

BY ALAIN FRIX

We live in a world where many products are of natural origin. They are part of our daily lives, and sometimes we don't realise it at all. And we probably don't fully understand the industries behind these renewables.

An example of such an industry is the pine chemical industry, which encompasses all products from the conifer processing industry.

This article attempts to describe very briefly the general dynamics of the pine chemical market, how the demand of the different industries evolves according to new opportunities, and its impact on materials and availability.

An ideal platform to understand the complexity of the pine chemical industry is the annual International Conference organised by the Pine Chemicals Association (PCA), led by its President & CEO Mrs Amanda Young. Many relevant and important topics are discussed there, as was the case at the Pine Chemicals Association International Conference 2022, which was successfully held in Denver, CO, USA, from 25th to 27th September.

Conifers capture several billion tons of carbon dioxide from the atmosphere each year. They patiently integrate the carbon parts into a very complex biomass, whose molecules - all biochemical - will find many industrial applications such as lumber, paper and a myriad of useful chemicals that are grouped under the term "pine chemicals".

Pine chemicals are very important raw materials for adhesives, inks, emulsifiers, soaps, detergents, automotive, pharmaceuticals, animal feed, construction, agriculture, paints, cleaners, food, perfumes, camphor, and recently they are facing a strong demand for biofuels, which is changing some of the traditional dynamics.

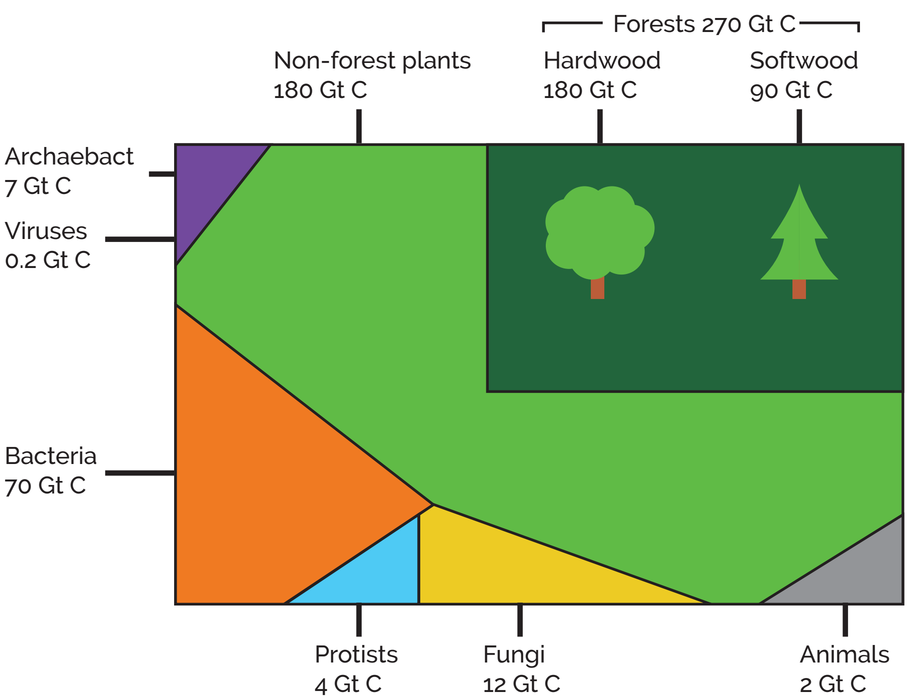
There are hundreds of pine chemicals, but the main commercial products are lignosulfonates, tall oil rosins, tall oil fatty acids, tall oil pitches, and gum rosins.

Smaller products such as crude sulphate turpentine (CST) and turpentine gum (GT) are probably familiar to you, although they represent only a fraction of the chemicals in the pinewood. Yet, for the perfume industry, the availability of turpentine is extremely important: without turpentine, and especially without its derivatives, perfumers would have to create perfumes in absence of dihydromyrcenol, Iso E Super, terpineol, synth sandalwood, iso bornyl cyclohexanol IBCH, iso camphyl cyclohexanol ICCH, etc. The non-availability of turpentine would remove 15% of the perfume ingredient palette by weight. More importantly, this would divide the existing renewability of fragrances by two, leaving mainly essential oils as the only substantial supplier of renewable materials. In this case, it would then be very likely that petrochemically derived ingredients would replace the void left by turpentine, due to cost. In other words, fragrances would become even less renewable.

LET'S TRY TO GO BACK UP THE BIOMASS CHAIN

Conifers are part of a very important biomass since - according to several studies of the United Nations and a recent study of the US National Academy of Sciences (PNAS) - coniferous (softwood) forests are among the largest reserves of "living" carbon in the world (**Fig-1**).

FIG-1 THE BIOMASS DISTRIBUTION ON EARTH



There are about 550 gigatons of carbon (Gt C) of biomass distributed among all kingdoms of life.

Source: The Biomass Distribution on Earth, May 21, 2018.
Proceedings of the National Academy of Science (PNAS), USA 115 (25) 6506-6511

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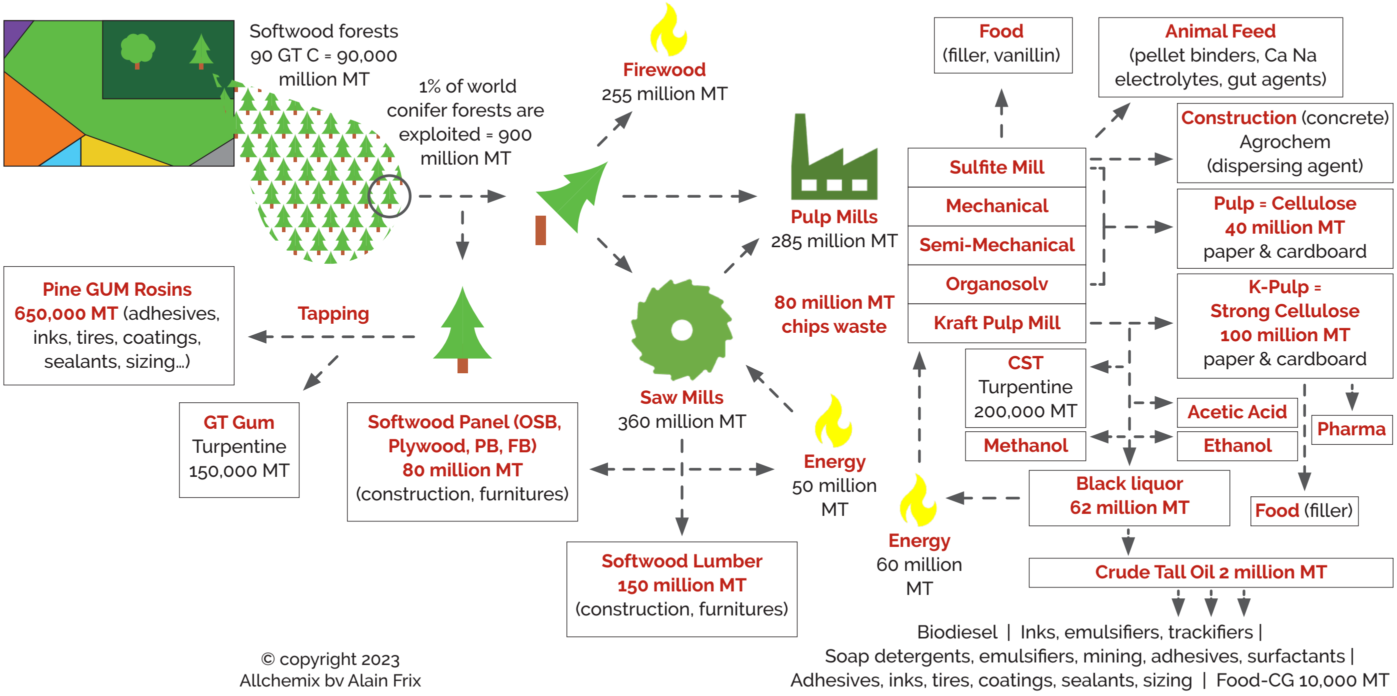
FIG-2 GLOBAL SOFTWOOD BIOMASS FLOW (IN MT OF C)



These coniferous forests are relatively little used by people (nearly 1% of the world's supply is exploited) because they are often inaccessible, being particularly present in boreal, cold, and swampy regions.

It is estimated that just under one billion tonnes of conifers are felled each year, often in a controlled and responsible manner. After a first natural drying in forests, the trunks are sent to sawmills and paper mills. Local consumption for domestic firewood is important, but sawmills are the biggest consumers of wood. These sawmills generate a lot of wood waste that is, most of the time, recycled or sent to paper mills that add it to the wood coming directly from the forests.

Paper mills all have, as a key objective, to extract cellulose fibres from wood, these are D-glucose biopolymers and main constituents of the plant cell wall. Cellulose represents nearly 40% of the weight of dry wood. This extraction requires a significant amount of energy and water, in particular to decompose the lignin fibres, a real plant cement that represents 28% of the dry weight of the tree. It is after pressing and drying the cellulose pulp that we obtain paper or cardboard. The world consumption of cardboard is increasing as the packaging of choice for e-commerce items.

These wood, panel, and paper industries have a combined estimated turnover of over US$250 billion per year and represent a significant income for many areas. According to their transformation process from wood to paper, paper mills will generate an important series of organic co-products that are much varied and very useful to a dozen industries.

Fig-2 shows in a schematic and simplified way the biomass flows that feed different industries.

The rapid shift in global demand towards more renewable consumer products and the evolution of biodiesel subsidies are strongly impacting biomass prices and allocations, especially for crude tall oil derivatives (**Fig-3**).

Some organic resources that have had industrial applications for decades are now being used for biofuel. This raises many questions because the granting of public subsidies by some countries to burn natural resources that are very useful for other industries seems to be a nonsense in relation to a sustainable economic policy.

In socio-economic terms, the conifer industry is a great provider of jobs in rural areas. Not only sawmill and pulp mill activities, but even a smaller industry such as pine gum tapping is a labour intensive industry: the number of farmers involved in tapping itself has been greater than 100,000, and over 300,000 people are very likely relying on the pine gum industry for a living worldwide, including farmers, crude gum collectors, dealers, and gum rosin processing operators.

SEEDS FOR A NEW CHEMISTRY

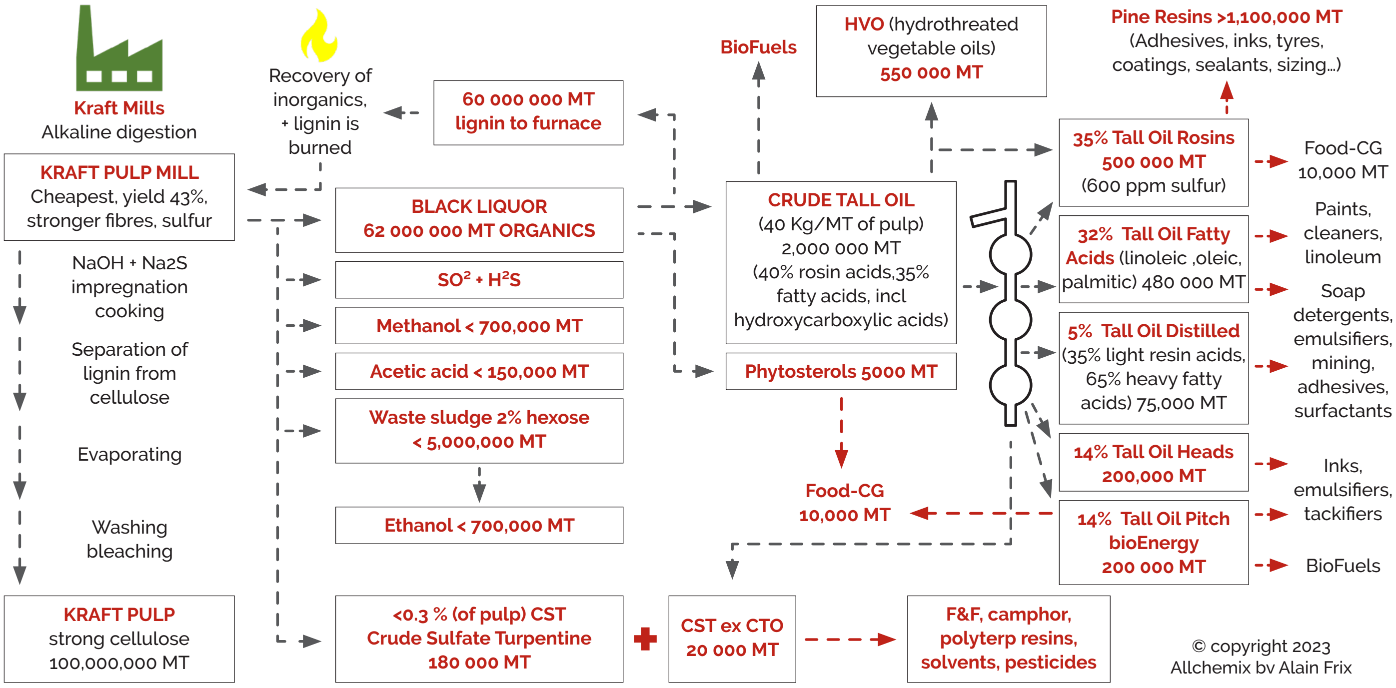
The petrochemical industry - with an output of over 400 million MT per year - has needed 150 years to produce polymers with some efficiency and minimise waste. The coniferous chemistry industry, although much smaller, is becoming a hub for the development of a new chemistry, that of new polymers of natural origin, similar to petrochemical polymers.

With an industrial access to 900 million MT of organic products, the conifer biomass industry is certainly destined for a promising future.

This renewable chemistry can also be combined with petrochemistry, and "hybrid" molecules, partially petrochemical and partially from biomass, being produced with good traceability.

Not to be confused with the concept of "mass balance" which is mainly limited to certifying the mixtures

FIG-3 KRAFT PULP MILLS & CRUDE TALL OIL



of organic materials (x% oil and y% biomass) before the cracking process in refineries (**Fig-4**).

However, the technology is still far from optimal: nature is recalcitrant, many very complex molecules such as lignin from conifers, are extremely difficult to process and to "simplify" if one wants to break them down into monomers in a reproducible way. And yet this is necessary in order to recreate polymers similar to those of the petrochemical industry. It will take years for humankind to create the optimal conditions and to cleverly break down wood, which nature has patiently done for millions of years by breaking down fossil biomass into oil. In addition to the technicality, the interactions between global industries, and political subsidies, make conifer biomass a very complex sector. **Fig-5** provides a snapshot of what this industry might look like today.

In a later work, pine chemicals experts such as Mr Michel Baumassy (Forchem Oy), Mr Alex Cunningham (BPC Institute), Mr Leonardo Siquiera (Argus Media), Mr Vitaly Rogachevsky (Vitrina LLC.), Dr Emmanuel Cazeils (Firmenich-DRT), Pierre Saricassapian (Firmenich-DRT), will be invited to share their views on the complexities and the specificities of CTO derivatives, biofuel, and other pine chemical products.

FIG-4 FUTURE CONJUNCTION OF BIOMASS CHEMICALS AND PETROCHEMISTRY HYBRID MOLECULES FROM PETRO + BIOMASS, DIFFERENT CONCEPT THAN MASS BALANCE

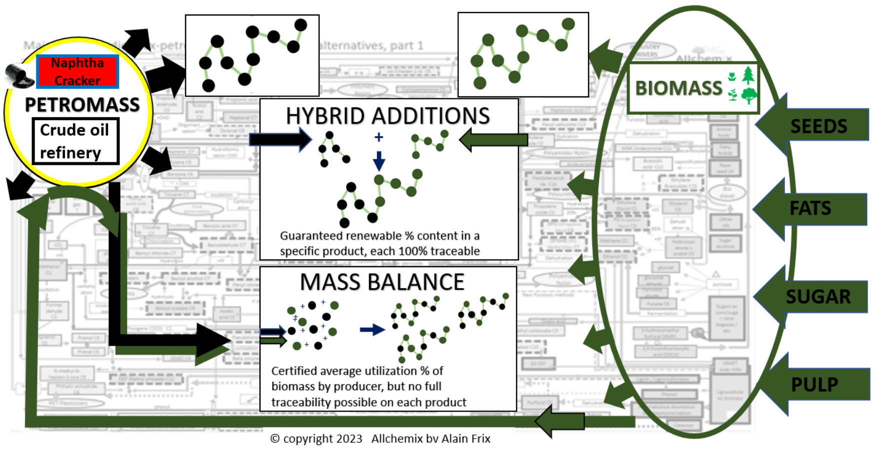


FIG-5 OVERVIEW TODAY'S GLOBAL SOFTWOOD BIOMASS STREAMS